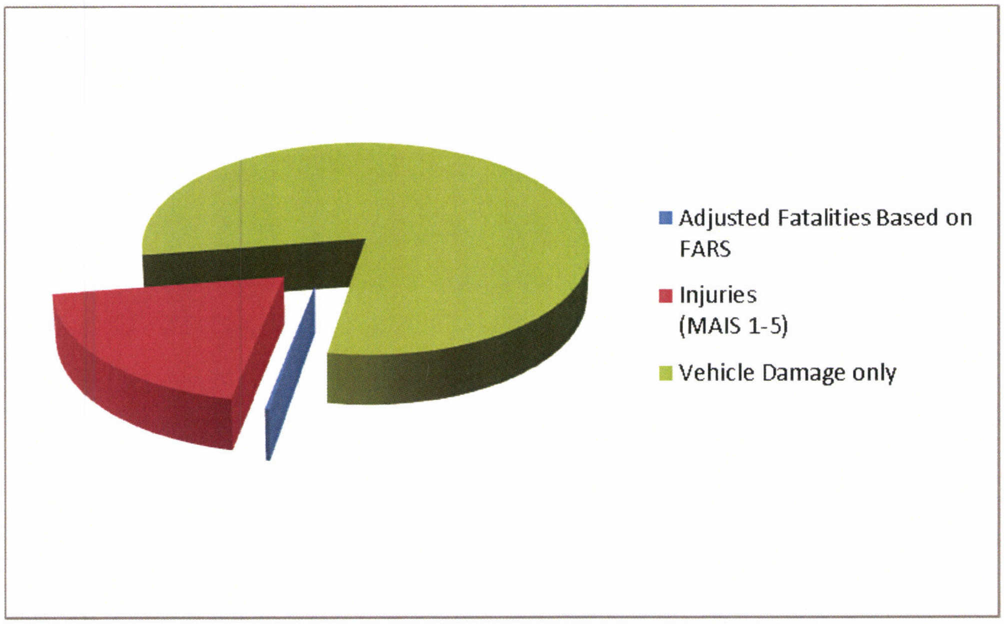
Figure III-2 22 Target Light-Vehicle Pre-Crash Scenario Crash Statistics

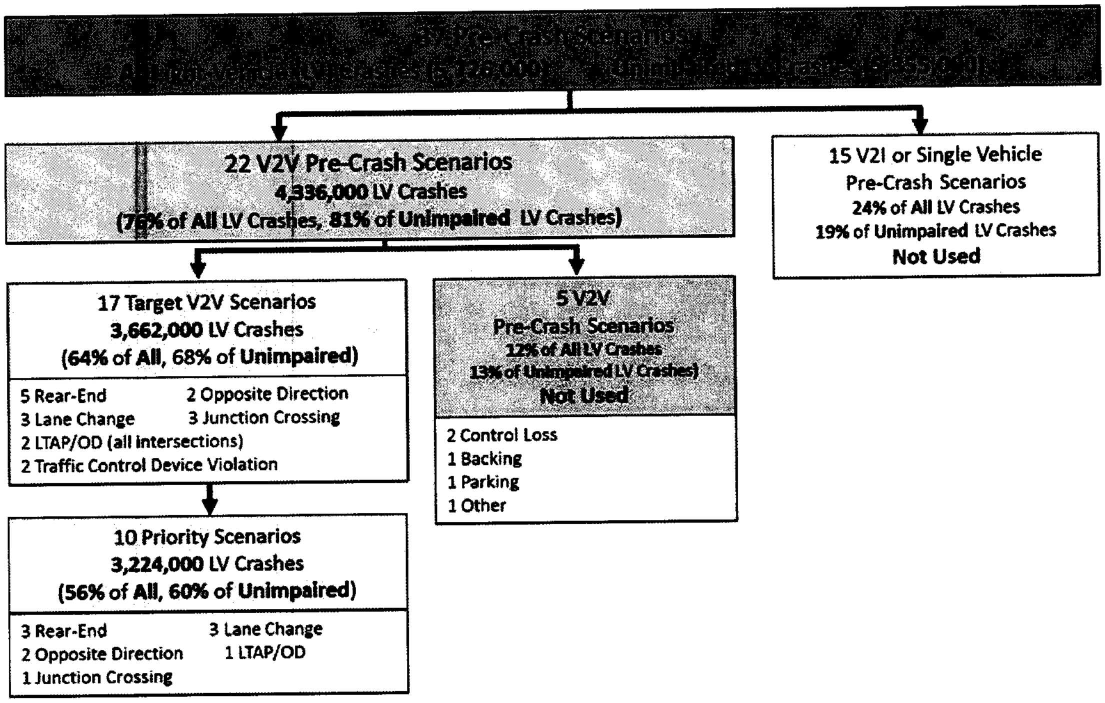


This analysis included the potential crashes that could be addressed by V2V technology only, V2I technology only, and combined. Overall, the DOT analysis concluded that, as a primary countermeasure, a fully mature V2V system could potentially address:

- about 4,409,000 police-reported or 79 percent of <u>all vehicle</u> target crashes,
- 4,336,000 police-reported or 81 percent of all <u>light-vehicle</u> target crashes, and
- 267,000 police-reported or 81 percent of all <u>heavy-truck</u> target crashes annually.

Figure III-3 provides a graphical representation of how the potential crashes that could be addressed by V2V technology only were derived.

Figure III-3 V2V Light-Vehicle Target Crashes Breakdown



In addition, the analysis also indicated V2I systems could potentially address:

- about 1,465,000 police-reported or 26 percent of all-vehicle target crashes,
- 1,431,000 police-reported or 27 percent of all light-vehicle target crashes, and
- 55,000 police-reported or 15 percent of all heavy-truck target crashes annually.

And, finally, combined V2V and V2I systems could potentially address:

- about 4,503,000 police-reported or 81 percent of all-vehicle target crashes,
- 4,417,000 police-reported or 83 percent of all light-vehicle target crashes, and
- 272,000 police-reported or 79 percent of all heavy-truck target crashes annually.[34]

This preliminary analysis estimated the annual frequency of three different types of target crashes (i.e., light-vehicle, heavy-truck, and all-vehicle crashes) based on data from the General Estimates System (GES) crash database for 2005-2008, where: (1) Light-vehicle crashes are those that involve at least one light vehicle with gross vehicle weight rating (GVWR) of 10,000

[34] Id.

pounds or less; (2) Heavy-truck crashes are those that involve at least one heavy truck, single unit or multiple units, with GVWR over 10,000 pounds; and (3) All-vehicle crashes are those crashes involving both light vehicles and heavy trucks. The number of crashes reported by police for the crash types used in this analysis corresponds to the number of target crashes that might be addressed. The preliminary analysis also excluded drivers with physiological impairments (e.g., intoxication, drowsiness) because such driver conditions could be addressed by autonomous, vehicle-based, countermeasure systems.

This preliminary estimate of annual crash frequency is broader than the benefits estimates used in Section XII below. Those estimates focus only on the usage of two applications (IMA and LTA). These applications are currently viewed as only able to be implemented by V2V technology. The estimates in Section XII, also do not take into account any potential V2I or autonomous applications, given that the agency is evaluating the readiness of V2V and not V2I or autonomous applications.

Once the preliminary analysis of which crashes V2V could potentially address was complete, the agency then focused its research efforts to develop priority scenarios based on the 10 highest comprehensive cost and functional years lost values identified in Table III-2. The fatalities, injuries, and property damage caused by each of the crashes that occurred underlie the Comprehensive Costs and Functional Years Lost.

Table III-2 Societal Cost and Ranking of 22 Target Light-Vehicle Pre-Crash Scenarios

Pre-Crash Scenario	Light Vehicle V2V Crashes					
	Comprehensive Cost			Functional Years Lost		
	Total	Percent	Rank	Total	Percent	Rank
Control loss/no vehicle action	$64,744,000,000	23.5%	1	469,000	24.1%	1
SCP @ non-signal	$41,095,000,000	14.9%	2	292,000	15.0%	2
Rear-end/LVS	$29,716,000,000	10.8%	3	198,000	10.2%	4
Opposite direction/no maneuver	$29,558,000,000	10.8%	4	213,000	11.0%	3
Running red light	$18,274,000,000	6.6%	5	129,000	6.6%	5
LTAP/OD @ non-signal	$15,481,000,000	5.6%	6	111,000	5.7%	6
LTAP/OD @ signal	$14,777,000,000	5.4%	7	105,000	5.4%	7
Rear-end/LVD	$12,215,000,000	4.4%	8	82,000	4.2%	8
Rear-end/LVM	$10,342,000,000	3.8%	9	72,000	3.7%	9
Changing lanes/same direction	$8,414,000,000	3.1%	10	60,000	3.1%	10
Control loss/vehicle action	$7,148,000,000	2.6%	11	51,000	2.6%	11
Turning/same direction	$6,176,000,000	2.2%	12	43,000	2.2%	12
Opposite direction/maneuver	$3,500,000,000	1.3%	13	25,000	1.3%	13
Drifting/same direction	$3,483,000,000	1.3%	14	25,000	1.3%	14
Running stop sign	$3,075,000,000	1.1%	15	22,000	1.1%	15
Rear-end/striking maneuver	$2,381,000,000	0.9%	16	16,000	0.8%	16
Parking/same direction	$1,095,000,000	0.4%	17	8,000	0.4%	17

Turn @ non-signal	$930,000,000	0.3%	18	6,000	0.3%	18
Turn right @ signal	$908,000,000	0.3%	19	6,000	0.3%	18
Backing into vehicle	$874,000,000	0.3%	20	6,000	0.3%	18
Rear-end/LVA	$667,000,000	0.2%	21	5,000	0.3%	21
Other	$76,000,000	0.0%	22	-	0.0%	22
All	$274,929,000,000	100.0%		1,944,000	100.0%	

Comprehensive economic costs account for goods and services that must be purchased, or productivity that is lost, as a result of motor vehicle crashes. Comprehensive costs encompass medical, emergency medical service, market productivity, household productivity, insurance administration, workplace productivity, legal and court, travel delay, and property damage costs. In addition, comprehensive costs include the value of a statistical life, the value of quality-adjusted life-years, and pain and suffering.

Functional years lost is a non-monetary measure that sums the years of life lost to fatal injury and the years of functional capacity lost to nonfatal injury. This measure does not mirror the monetary economic cost. It assigns a different value to the relative severity of injuries suffered from motor vehicle crashes. Table III-2 provides the annual values of comprehensive costs and functional years lost for the 22 target pre-crash scenarios involving two or more light vehicles based on 2004-2008 GES crash statistics of injured persons. These cost estimates reflect the injury levels of persons involved in only police-reported crashes.

Based on the target light vehicle crashes that can be addressed by V2V technology, Table III-3 extracts the number of crashes, injuries, and fatalities that form the basis for the development of the Comprehensive Cost and Functional Year Lost measures. Additional information regarding this data is available in Section XII.

Table III-3 Light-Vehicle 2004-2008 GES Averages for V2V Target Pre-Crash Scenarios

Pre-crash Scenario Group	Pre-crash Scenario	Total No. Of crashes	MAIS Injury Code 0 None	1 Minor	2 Moderate	3 Serious	4 Severe	5 Critical	6 Fatal	Adj. Fatalities Based on FARS
Rear End	LVS	942,000	204,027	299,750	33,389	8,815	1,761	562	811	1,080
	LVD	398,000	77,805	115,948	13,082	3,542	720	230	397	528
	LVM	202,000	42,752	66,363	7,866	2,288	480	163	701	933
	Striking Maneuver	83,000	11,948	19,420	2,242	626	128	44	111	147
	LVA	21,000	4,465	6,320	750	223	47	16	14	19
Lane Change	Same Direction	336,000	34,501	53,356	6,677	2,118	464	163	504	672
	Turn - Same Direction	202,000	28,491	39,850	4,893	1,511	325	116	379	504
	Drift - Same Lane	105,000	12,530	18,208	2,260	706	155	51	222	295
Opposite Direction	Maneuver	11,000	2,519	6,433	1,036	435	106	41	417	556
	No Maneuver	118,000	25,589	58,025	9,035	3,660	875	344	3,501	4,663
LTAP/OD	@ Non Signal	184,000	50,160	89,482	11,644	3,830	853	296	970	1,293
	@ Signal	204,000	62,164	108,673	13,940	4,450	975	334	605	805
Junction Crossing	SCP@ Non Signal	647,000	149,611	245,533	31,290	10,045	2,214	762	2,641	3,517
	Turn Right @ Signal	31,000	3,474	5,388	603	153	29	9	77	103
	Turn @ Non Signal	45,000	5,408	7,811	925	263	54	18	38	50
	Total	3,529,000	715,444	1,140,560	139,632	42,665	9,186	3,149	11,388	15,165
	Total All Light Vehicle Crashes	5,764,645	995,019	1,712,336	220,355	71,756	15,883	5,591	25,885	
	% of Total Light Vehicle Crashes	61	72	67	63	59	58	56	44	

From the 10 pre-crash scenarios prioritized by the agency, CAMP identified five initial, prototype V2V safety applications that could address these scenarios. It was found that these prototype applications could also address seven other pre-crash scenarios that were included in the overall list of 22 addressable by V2V, as shown in Table III-4 (Note: acronyms used in tables are explained in the list of acronyms at the front of this report). This includes the V2I safety application Traffic Control Device Violation pre-crash scenarios that can be addressed by the V2V Intersection Movement Assist safety application.

Table III-4 Groups of Target Light-Vehicle V2V Pre-Crash Scenarios and Associated Societal Cost

Pre-Crash Scenario/Safety Application		Light Vehicles V2V Crashes: Comprehensive Cost Total	Comprehensive Cost Percent	Comprehensive Cost Rank	Functional Years Lost Total	Functional Years Lost Percent	Functional Years Lost Rank
Rear End/Forward Collision Warning	Rear-end/LVS	$ 29,716,000,000	10.8%	3	198,000	10.2%	4
	Rear-end/LVD	$ 12,215,000,000	4.4%	8	82,000	4.2%	8
	Rear-end/LVM	$ 10,342,000,000	3.8%	9	72,000	3.7%	9
	Rear-end/striking maneuver	$ 2,381,000,000	0.9%	16	16,000	0.8%	16
	Rear-end/LVA	$ 667,000,000	0.2%	21	5,000	0.3%	21
	Total	**$ 55,321,000,000**	**20.1%**		**373,000**	**19.2%**	
Lane Change/Blind Spot- Lane Change Warning	Changing lanes/same direction	$ 8,414,000,000	3.1%	10	60,000	3.1%	10
	Turning/same direction	$ 6,176,000,000	2.2%	12	43,000	2.2%	12
	Drifting/same direction	$ 3,483,000,000	1.3%	14	25,000	1.3%	13
	Total	**$ 18,073,000,000**	**6.6%**		**128,000**	**6.6%**	
Opposite Direction/Do Not Pass Warning	Opposite direction/no maneuver	$ 29,558,000,000	10.8%	4	213,000	11.0%	3
	Opposite direction/maneuver	$ 3,500,000,000	1.3%	13	25,000	1.3%	13
	Total	**$ 33,058,000,000**	**12.0%**		**238,000**	**12.2%**	
LTAP/OD/ Left Turn Assist Warning	LTAP/OD @ non signal	$ 15,481,000,000	5.6%	6	111,000	5.7%	6
	LTAP/OD @ signal	$ 14,777,000,000	5.4%	7	105,000	5.4%	7
	Total	**$ 30,258,000,000**	**11.0%**		**216,000**	**11.1%**	
Junction Crossing/Intersection Movement Assist	SCP @ non signal	$ 41,095,000,000	14.9%	2	292,000	15.0%	2
	Turn @ non signal	$ 930,000,000	0.3%	18	6,000	0.3%	18
	Turn right @ signal	$ 908,000,000	0.3%	19	6,000	0.3%	18
	Total	**$ 42,933,000,000**	**15.6%**		**304,000**	**15.6%**	
Traffic Control Device Violation	Running red light	$ 18,274,000,000	6.6%	5	129,000	6.6%	5
	Running stop sign	$ 3,075,000,000	1.1%	15	22,000	1.1%	15
	Total	**$ 21,349,000,000**	**7.8%**		**151,000**	**7.8%**	

The Safety Applications identified in Table III-4, except for the V2I safety application Traffic Control Device Violation, are represented by prototype applications in the Safety Pilot Model Deployment. These prototypes were developed by a consortium of OEMs working collaboratively in a pre-competitive environment. Data has been collected that provides information about the functional nature of these safety applications being used by regular drivers under real driving conditions. Analysis of the first 6 months of data identified the safety applications that most drivers experienced and for which the most data was collected. These safety applications were Forward Collision Warning, Intersection Movement Assist, Left Turn Assist, and Blind Spot Warning/Lane Change Warning. The amount of preliminary data collected on these four safety applications provided the information needed to estimate possible effectiveness and benefits these safety application may generate.

B. Potential for V2V to address vehicle crashes

The discussion up to this point has focused on determining the universe of crashes that V2V could address, and how a research program was developed and executed to prototype safety applications to address those crashes. The data collected during the Safety Pilot Model Deployment provide an indication of functional feasibility, along with information to evaluate the system – in effect, *whether* the prototypes and the system worked, but not necessarily *how well* they worked. Based on the information available to the agency at this time, Section XI starts to take the next step to analyze potential effectiveness and benefits that may accrue if these systems are implemented in the real world at production volumes.

In mass deployment, though, the agency would not expect benefits to accrue immediately. When V2V technology first begins to enter the fleet, it is possible (perhaps even likely) that vehicles equipped with the technology will encounter relatively few other vehicles also equipped with the technology – i.e., that V2V devices may not be able to "find" each other for a while. Even if the market drives faster uptake by consumers of aftermarket devices (if, for example, auto insurance companies offer discounts for installing the devices), which would increase the ability of V2V devices to find each other earlier on, it will still take 37 years before we would expect the technology to fully penetrate the fleet. As a result, full knowledge of how different aspects of the V2V system perform – the ability of the security system to manage certification revocation lists for the complete U.S. vehicle fleet, for example – may be delayed.

However, as explained in Section XII, benefits would begin to appear in the first year. On the other hand, costs for the security system would be lower during initial deployment because there would be fewer vehicles requiring certificates. Over the 37 years, costs would increase in parallel with increased fleet penetration. Section XI discusses this issue of gradual roll-out of V2V technology and its implications in more detail.

While a safety application as initially developed by an OEM or supplier may only address a subset of the pre-crash scenarios in the group, over time the safety application may be updated to include the other pre-crash scenarios as the technology and knowledge evolves.

Another factor affecting costs and benefits would be what combination of safety applications are deployed in various vehicles. V2V devices in various vehicles may not be able to support all the safety applications.[35] Depending on the type of device, different data elements may or may not be available, which may limit what safety applications can be supported. For example, a device that does not connect to a vehicle data bus may support forward collision warning, but without turn signal information, it may not support/implement left turn assist warning.

The agency notes that crashes that can be prevented and lives that can be saved depends on the effectiveness of the safety applications. This report evaluates effectiveness estimates for two potential applications, IMA and LTA, but not for other potential safety applications such as LCW, FCW, CSW, etc.

As such, the overall potential of V2V and the number of crashes prevented and lives saved is highly dependent on the number of safety applications deployed, the penetration of those applications in the fleet and the way in which the applications operate. For additional information on potential crashes prevented and lives saved using the IMA and LTA applications please refer to Section XII.

C. Ways of addressing the safety need

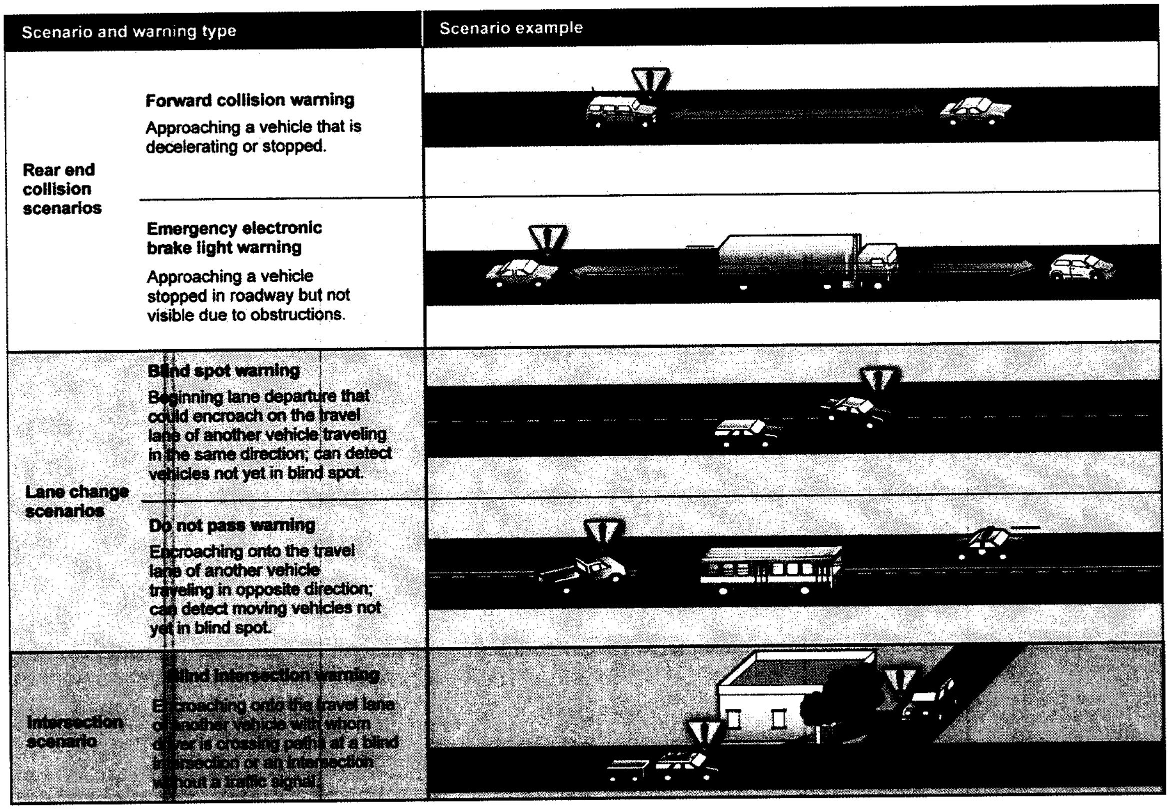
1. Scenarios addressed uniquely by vehicle-to-vehicle communications

V2V technology communicates via radio signals, which are omnidirectional (i.e., offer 360 degrees of coverage). Communicating via these signals allows two equipped vehicles to "see" each other at times when other vehicles that are only relying on their sensors are not able to detect the presence of another vehicle, let alone determine the other vehicle's heading, speed, or its operational status. Figure III-4 depicts examples of safety applications and the scenarios they can address.

---

[35] Description of Light-Vehicle Pre-Crash Scenarios for Safety Applications Based on Vehicle-to-Vehicle Communications (Report No. DOT HS 811 731, May 2013). See www.nhtsa.gov/Research/Crash+Avoidance/Office+of+Crash+Avoidance+Research+Technical+Publications (last accessed Jan. 27, 2014)

Figure III-4 Examples of Crash Scenarios and Vehicle-to-Vehicle Applications



Source: GAO analysis of Crash Avoidance Metrics Partnership information.

NOTE: Sensor-based crash avoidance technologies can, in some instances, provide warnings in forward collision, blind spot, and do not pass scenarios

V2V communications also offer an operational range of up to 300 meters between vehicles to facilitate identification of intersecting paths that may potentially result in a crash if no driver or vehicle action is taken. Additionally, a V2V system is not subject to the same weather, light, or cleanliness constraints associated with vehicle-resident sensors (e.g., cameras, lidar), although it is subject to other issues (e.g., urban canyons, GPS signal).[36]

There are three V2V safety applications that the agency believes are enabled by V2V alone and could not be replicated by any current, known vehicle-resident sensor- or camera-based systems, as discussed below.

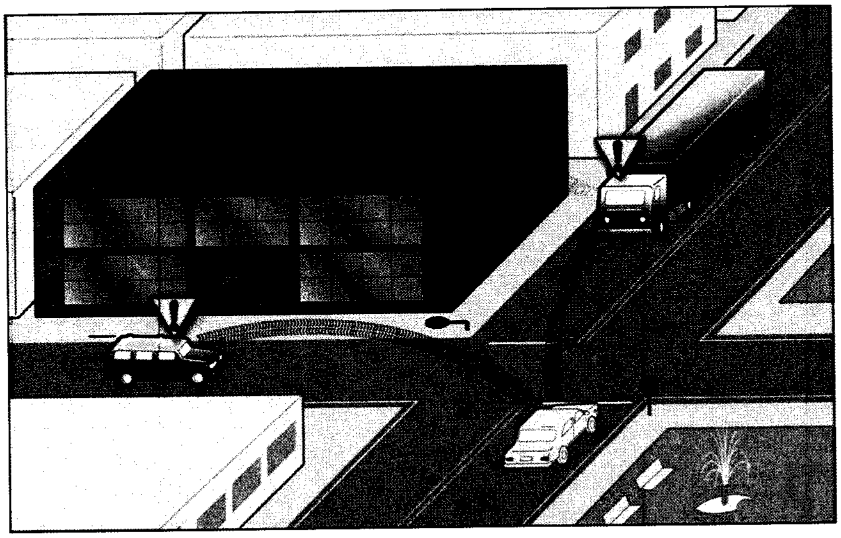
---

[36] A lidar device detects distant objects and determines the ir position, velocity, or other characteristics by analysis of pulsed laser light reflected from the ir surfaces. Lidar operates on the same principles as radar and sonar.

a) Intersection Movement Assist

IMA warns the driver of a vehicle when it is not safe to enter an intersection due to a high probability of colliding with one or more vehicles at intersections both where a signal is present (a "controlled" intersection) and those where only a stop or yield-sign is present (an "uncontrolled" intersection). Figure III-5 illustrates one possible IMA scenario.

Figure III-5 Example of V2V Intersection Movement Assist Warning Scenario



Source: GAO.

Note: In this scenario, the truck and sports utility vehicle are at risk of colliding because the drivers are unable to see one another approaching the intersection and the stop sign is disabled. Both drivers would receive warnings of a potential collision, allowing them to take actions to avoid it.

b) Left Turn Assist

LTA warns the driver of a vehicle, when they are entering an intersection, not to turn left in front of another vehicle traveling in the opposite direction.

c) Emergency Electronic Brake Light

Emergency Electronic Brake Light enables a vehicle to warn its driver to brake in a situation where another V2V-equipped vehicle decelerates quickly but may not be directly in front of the warning vehicle. The EEBL warning is particularly useful when the driver's line of sight is obstructed by other vehicles or bad weather conditions, such as fog or heavy rain.

2. Scenarios also addressed by vehicle sensor-based systems

Two of the applications being evaluated by the agency are already available in production vehicles using vehicle-resident sensors: FCW and BSW. These applications have been available in a small number of production vehicles for many years. They could be considered mature technologies, insofar as they have undergone multiple generations of sensor technologies and variations of sensing technology to achieve their implementation.

V2V technology, however, could enable these applications independent of any vehicle-resident sensors (e.g., cameras or lidar). At the same time, V2V could provide additional detection range for these applications, and/or detection agnostic to the weather, light or cleanliness constraints associated with vehicle-resident sensors such as cameras or lidar.

a) Forward Collision Warning

FCW warns the driver of the host vehicle in case of an impending rear-end collision with a remote vehicle ahead in traffic in the same lane and direction of travel.

The agency believes, based on current technology, that FCW systems using radar or cameras cannot provide a warning fast enough for very high speed rear end crashes. V2V, in contrast, has that capability based on its longer range (300 meters). Thus, fatal rear end crashes are one area where we believe V2V can provide some benefits not potentially covered by radar- and camera-based systems.

Radar and camera FCW systems also have a problem detecting stopped vehicles if the vehicle is stopped before coming into range of the radar and camera. Recently, dual radar and dual camera systems have been developed to provide detection of stopped vehicles. A V2V system could act as the redundant system and allow a single radar or single camera FCW system to detect stopped vehicles, thus reducing system cost as compared to dual radar or dual camera.

b) Blind Spot Warning + Lane Change Warning

Blind Spot Warning +Lane Change Warning warns the driver of the host vehicle during a lane change attempt if the blind spot zone into which the host vehicle intends to switch is, or will soon be, occupied by another vehicle traveling in the same direction. The application also provides the driver of the host vehicle with advisory information that a vehicle in an adjacent lane is positioned in a vehicle's "blind spot" zone when a lane change is not being attempted.

3. Scenarios possibly addressed by a combination of vehicle resident sensors and V2V communications

Other sensors such as radar, lidar, and cameras enable certain safety applications that are viewed by some as alternatives to V2V. While these systems might be more mature than V2V, they also have drawbacks when used alone; a combined or fused system using any of these other sensors along with V2V will take advantage of the benefits of DSRC. For example, detection of threat vehicles not in the sensors' field of view, and using a DSRC signal to validate a return from a vehicle-based sensor (i.e., a radar return off metal objects in the roadway, absent a DSRC signal identifying the sender as a vehicle, may be mistaken for a vehicle and cause a false warning).

A fused system would be able to use multiple sensors to augment accuracy, and could lead to improved warning timing and a reduction in the number of false positives. As stated in the agency policy statement on automated vehicles,[37] V2V technology could potentially also act as an additional sensor input that could augment data available.

D. Types of V2V devices

1. OEM devices

An OEM device is an electronic device built or integrated into a vehicle during vehicle production. An integrated V2V system is connected to proprietary data busses and can provide highly accurate information using in-vehicle information to generate the Basic Safety Message. The integrated system both broadcasts and receives BSMs. In addition, it can process the content of received messages to provide advisories and/or warnings to the driver of the vehicle in which it is installed. Because the device is fully integrated into the vehicle at the time of manufacture, vehicles with Integrated Safety Systems could potentially provide haptic warnings to alert the driver (such as tightening the seat belt or vibrating the driver's seat) in addition to audio and visual warnings provided by the aftermarket safety devices. It is expected that the equipment required for an integrated OEM V2V system would consist of a general purpose processor and associated memory, a radio transmitter and transceiver, antennas, interfaces to the vehicle's sensors, and a GPS receiver. Such integrated systems are capable of being reasonably combined with other vehicle-resident crash avoidance systems to exploit the functionality of both types of systems.

2. Aftermarket devices

a) Definition of an "aftermarket" device

Generally speaking, automotive aftermarket devices can be defined as any product with one or more functions in the areas of comfort, convenience, performance, or safety, which are added to a motor vehicle after its original assembly. An aftermarket V2V communication device provides advisories and warnings to the driver of a vehicle similar to those provided by an OEM-installed V2V device. These devices, however, may not be as fully integrated into the vehicle as an OEM device, and the level of connection to the vehicle can vary based on the type of aftermarket device itself. For example, a "self-contained" V2V aftermarket safety device could only connect to a power source, and otherwise would operate independently from the systems in the vehicle. Aftermarket V2V devices can be added to a vehicle at a vehicle dealership, as well as by authorized dealers or installers of automotive equipment. Some aftermarket V2V devices (e.g., cell phones with apps) are portable and can be standalone units carried by the operator, the passenger, or pedestrians.

[37] See www.nhtsa.gov/staticfiles/rulemaking/pdf/Automated_Vehicles_Policy.pdf (last accessed Feb. 20, 2014).

b) Types of aftermarket devices used in Safety Pilot Model Deployment

In the Safety Pilot Model Deployment, three types of aftermarket devices were installed into vehicles: vehicle awareness devices, aftermarket safety devices, and retrofit safety devices.

The VAD is the simplest design, and it only transmits a BSM to nearby vehicles. A VAD does not have any safety applications or DVIs, and it cannot provide any advisories or warnings to a driver. Installing these devices on existing vehicles could be an attractive option for fleet operators, rental agencies, or vehicle owners who could see benefit in signaling the presence of their vehicles to V2V-equipped vehicles and thus potentially avoiding crashes. Installation of VADs could increase deployment of V2V systems across the fleet as a whole, and thus potentially could increase the benefits for early adopters of this technology.

The ASD (referred to as a "self-contained" device in this research report in contrast to the terminology used in the Safety Pilot Model Deployment), is similar to the VAD, but also has the ability to both receive and transmit a BSM to nearby vehicles. Also, it contains safety applications that can provide advisories or warnings to the driver. Three suppliers developed and tested self-contained devices for use with light vehicles in the Safety Pilot Model Deployment. All suppliers developed and tested the following safety applications:

- FCW
- EEBL
- CSW[38]

The safety applications and warning functionality in both the ASDs and the V2V vehicles were similar, but the three self-contained device suppliers implemented only audible warnings for their devices, with no visual or haptic advisories or warnings presented to the driver. The agency originally specified a visual display for these devices, but the display selected by the suppliers did not meet the distraction guidelines for the Safety Pilot Model Deployment and was, therefore, not implemented as part of that testing.

The RSD is more fully integrated than the ASD: it connects to the vehicle and receives information from the vehicle's data bus to support operation of various applications on the device. Although it is possible from a technical standpoint, light vehicles were not equipped with a RSD device in the Safety Pilot Modal Deployment, even though RSDs were deployed in heavy vehicles. The heavy truck RSDs demonstrated the following safety applications:

---

[38] Some self-contained devices also had IMA capabilities and were track tested outside of the Safety Pilot Model Deployment, but did not meet performance requirements for purposes of inclusion in Model Deployment.

- FCW
- EEBL
- CSW
- BSW
- IMA
- Bridge Height Information

The advantage to RSDs, as compared to the other types of aftermarket devices, is that they can potentially perform different or enhanced safety applications or execute more sophisticated applications because they can access a richer set of data (i.e., data from the data bus). For example, having information on the turn signal status from the vehicle provides the device and application an indication of possible driver intent to make a turn, which can help inform the LTA, DNPW, and BSW/LCW safety applications. Therefore, the RSD is considered to be the closest of all of the aftermarket devices to a V2V device integrated into a new vehicle. Table III-5 provides details on the three types of aftermarket safety devices employed in the Safety Pilot Model Deployment. The agency envisions these general types as models for potential commercial aftermarket devices that could be available to consumers.

Table III-5 Aftermarket Safety Device Types

Device Type	Definition	Method of Installation	Functionality
Vehicle Awareness Device	Device is able to be connected to the vehicle for power source. Device provides Basic Safety Message for surrounding vehicles.	Device would need to be installed by a certified installer on vehicles not equipped with V2V technology to ensure correct antenna placement and security. In the future, VADs might be mobile devices or stand-alone key fobs.	• Transmits BSM
Aftermarket Safety Devices (i.e., Self-contained)	Device is connected to the vehicle for power source, Device transmits BSM and receives BSMs to support safety applications for the driver of the vehicle in which it is installed.	This device only receives power from the vehicle; however, a certified installer would need to ensure correct antenna placement and security.	• V2V Safety applications • Receives and Transmits BSM • Driver-Vehicle Interface
Retrofit Safety Devices	Device is connected to the vehicle's data bus that provides BSM and safety applications for the driver of the vehicle in which it is installed.	This device needs to be connected to the vehicle's data bus, therefore would require an installer that can access this for the particular make of vehicle. Also, a certified installer would need to ensure correct antenna placement and security.	• V2V Safety applications • Receives and Transmits BSM • Driver Vehicle Interface • Integration into the vehicle data bus

3. Infrastructure-based devices

a) Infrastructure based devices that enable V2I

In addition to in-vehicle equipment, the Safety Pilot program is evaluating road side equipment with DSRC devices that allow vehicles to receive information from the infrastructure and allow vehicles to update their security certificates.[39]

This RSE can be co-located with infrastructure elements such as road signs, traffic signals, etc. The applications that the RSE is supporting in the Safety Pilot Model Deployment are signal phasing and timing (SPaT), and curve and curve speed warnings. There are twenty-six DSRC-equipped roadside units being used to support the program.

V2I communications involve the wireless exchange of critical safety and operational data between vehicles (including brought-in devices) and roadway infrastructure. V2I communications are intended primarily to avoid motor vehicle crashes while enabling a wide range of mobility and environmental benefits. The Connected Vehicle program is funding V2V and V2I communications research within the Dynamic Mobility Applications, Road Weather, AERIS, and V2I Safety programs.

b) What potential safety applications are enabled by V2I?

V2I applications complement the V2V safety applications by addressing crash scenarios that V2V applications cannot address and by more efficiently addressing some crash scenarios when there are low levels of penetration of DSRC-equipped light vehicles. The following is a list of contemplated, but not yet developed, V2I safety applications:

- Red Light Violation Warning: This technology will provide in-vehicle alerts to drivers about potential violations of upcoming red lights, based on vehicle speeds and distances to intersections.
- Curve Speed Warning: If a driver's current speed is unsafe for traveling through an upcoming road curve, this technology will alert the motorist to slow down.
- Stop Sign Gap Assist: This technology will assist drivers at STOP-sign-controlled intersections via vehicle gap detections, alerting motorists when it is unsafe to enter intersections.
- Reduced Speed Zone Warning: This technology will assist drivers in work zones, by issuing alerts to drivers to reduce speed, change lanes, and/or prepare to stop.
- Spot Weather Information Warning: This technology will provide in-vehicle alerts or warning to drivers about real-time weather events and locations, based upon information

[39] During the second phase of Safety Pilot, DSRC and cellular were used to provide vehicles with updated security certificates.

from Roadside Equipment connections with Transportation Management Center and other weather data collection sites/services.

- Stop Sign Violation Warning: Based on vehicle speeds and distances to intersections, this technology will provide in-vehicle alerts to drivers about potential violations of upcoming stop signs.
- Railroad Crossing Violation Warning: This technology will assist drivers at controlled railroad crossings via RSE connections with existing train detection equipment, alerting motorists when it is unsafe to cross the railroad tracks.
- Oversize Vehicle Warning: Drivers of oversized vehicles will receive an in-vehicle alert to take an alternate route or a warning to stop, based upon information from RSE connections to infrastructure at bridges/tunnels.

Implementation of these V2I applications would require additional data elements to be broadcast to, and processed by, vehicles. Since the broadcasting of additional data has the potential of leading to communication congestion, DOT's ITS JPO will conduct additional channel congestion analysis. It is critical that safety messaging should not be compromised due to broadcasting more data for V2I.

IV. Scope and Legal Authority

A. NHTSA's scope and legal authority and how it applies to vehicle to vehicle communication

The National Traffic and Motor Vehicle Safety Act (the "Safety Act") gives NHTSA broad statutory authority to regulate motor vehicles and items of motor vehicle equipment.[40] As applied in this context, the agency's authority includes all or nearly all aspects of a V2V system. Congress enacted the Safety Act in 1966 with the purpose of reducing deaths and injuries as a result of motor vehicle crashes and non-operational safety hazards attributable to motor vehicles.[41] The Safety Act, as amended, is now codified at 49 U.S.C. §§ 30101 et seq.

---

[40] For more discussion and analysis of NHTSA's authority to regulate advanced crash avoidance technologies, including V2V technologies, under the Safety Act, see the Potential Regulatory Challenges of Increasingly Autonomous Vehicles, 52 Santa Clara L. Rev. 1423 (Wood *et al.*, 2012) at http://digitalcommons.law.scu.edu/lawreview/vol52/iss4/9/ (last accessed Mar. 4, 2014).
For example, the agency's authority to address the privacy and security of vehicle data associated with the operation of those technologies is discussed at length. Id., at pp. 1448, 1465-72. Addressing data security is necessary to safeguard the effectiveness of these technologies and promote the ir acceptance by vehicle users. Addressing privacy is similarly necessary to promote public acceptance. The views expressed in that article fairly encompass the agency's views of its regulatory authority.

[41] H.R. Rep. No. 89-1776, at 10 (1966).

The vehicle technologies that enable vehicles to talk to each other and to communicate with infrastructure are vastly different from those that existed when the Safety Act was enacted. Then, the vehicle operating systems were largely mechanical and controlled by the driver via mechanical inputs and linkages. Components and systems were either designed into the vehicle at the time of original manufacture or were later attached to or physically carried into the vehicle. Sensing of a vehicle's performance and the roadway environment was done solely by the driver. Today, an increasing number of vehicle functions are electronic. These functions can be activated and controlled automatically and do not necessarily require driver involvement, unlike the mechanical functions of previous generations of vehicles. As discussed in much more detail in Section V.D below, V2V technologies rely on dedicated short-range radio communications (DSRC), which themselves require no driver involvement whatsoever in order to send and receive information that can be used for vehicle safety functions. Other ways in which V2V technologies differ from the mechanical technologies prevalent when the Safety Act was first enacted include the fact that how they operate can be substantially altered by post-manufacture software updates, and that advances in communications technology make it possible for nomadic devices with vehicle-related applications to be brought into the vehicle.

The language of the Safety Act, however, is broad enough to comfortably accommodate this evolution in vehicle technologies. NHTSA's statutory authority over motor vehicles and motor vehicle equipment would allow the agency to establish safety standards applicable both to vehicles that are originally manufactured with V2V communications technologies and to aftermarket equipment that could be added to vehicles that were not originally manufactured as V2V-capable (i.e., to convert them into vehicles with various degrees of V2V-capability).

In the Safety Act, which gives NHTSA authority over new motor vehicles and motor vehicle equipment, "motor vehicle" is defined as a "vehicle driven or drawn by mechanical power and manufactured primarily for use" on public roads.[42] The definition of "motor vehicle equipment," as cited below, is broader and thus effectively establishes the limit of the agency's authority under the Safety Act:

(A) any system, part, or component of a motor vehicle as originally manufactured;
(B) any similar part or component manufactured or sold for replacement or improvement of a system, part, or component, or as an accessory or addition to a motor vehicle; or
(C) any device or an article or apparel, including a motorcycle helmet and excluding medicine or eyeglasses prescribed by a licensed practitioner, that –
    i) is not a system, part, or component of a motor vehicle; and

[42] 49 U.S.C. § 30102(a)(6).

ii) is manufactured, sold, delivered, or offered to be sold for use on public streets, roads, and highways with the apparent purpose of safeguarding users of motor vehicles against risk of accident, injury, or death.[43]

NHTSA's authority to issue safety standards that apply to new motor vehicles would enable the agency to establish standards applicable to vehicles that were originally manufactured with V2V capabilities.[44] This authority would also extend to the individual pieces of equipment that are installed in new vehicles to provide them with V2V capabilities.[45] Using the agency's authority over equipment, as described in (B) and (C) above, NHTSA could also establish safety standards that apply to equipment used to equip vehicles (not originally manufactured with V2V capabilities) with V2V capabilities.[46]

NHTSA's authority over these groups of items – (1) systems, parts, and components installed or included in a vehicle, (2) replacements and improvements to those systems, parts, and components, (3) accessories and additions to motor vehicles, and (4) devices or articles with an apparent safety-related purpose – is very broad. The status of these items as motor vehicle equipment does not depend on the type of technology or its mode of control (mechanical or electronic) or whether an item is tangible or intangible. The transition from mechanical to electromechanical systems has thus had no significant effect on the extent of NHTSA's authority over motor vehicle performance. NHTSA continues to have regulatory authority under the Safety Act over all the systems, parts, and components installed on new motor vehicles, even as motor vehicle control systems become increasingly electronic, and perhaps increasingly automated, in the future.

---

[43] § 30102(a)(7)(C); MAP-21, Pub. L. 112-141, § 31201, 126 Stat. 405. See www.gpo.gov/fdsys/pkg/PLAW-112publ141/pdf/PLAW-112publ141.pdf (last accessed Jan. 27, 2014). Congress added subparagraph (C) to the statutory definition of "motor vehicle equipment" in 1970 when it amended the definition in order to clarify the Department's authority over additional objects such as motorcycle helmets. See S. Rep. No. 91-559, at 5 (1970). However, Congress did not seek to limit the extension of the Department's authority only to motorcycle helmets and instead utilized the broad terms "device, article, and apparel" to describe the universe of objects that are within the agency's authority. *See id.* Acknowledging the concerns of those who authored the House version of the amendatory language that utilizing the terms "device, article, and apparel" might unduly extend the Department's authority to objects that have only a tangential relation to motor vehicle safety, the conference committee added a use restriction. *See id.* Congress relaxed this use restriction in the statutory definition of "motor vehicle equipment" as part of the amendments to the Safety Act in MAP-21. *See* MAP-21, Pub. L. 112-141, § 31201, 126 Stat. 405. Thus, the Department's regulatory authority under subparagraph (C) is limited to those devices, articles, or apparel that are used for "*the apparent purpose* of safeguarding users of motor vehicles against risk of accident, injury, or death." See id. (Emphasis added.)

[44] 49 U.S.C. §§ 30102(a)(6), 30111.

[45] 49 U.S.C. § 30102(a)(7)(A).

[46] 49 U.S.C. § 30102(a)(7)(B).

Put in the context of V2V-related motor vehicle equipment, NHTSA considers the following items subject to the agency's regulatory authority:

(1) Any integrated original equipment (OE) used for V2V communications or safety applications reliant on V2V communications
(2) Any integrated aftermarket equipment used for V2V communications or safety applications reliant on V2V communications[47]
(3) Some non-integrated aftermarket equipment, depending on its nature and apparent purpose[48]
(4) Software that provides or aids V2V functions, and software updates to all of this equipment[49]
(5) Some roadside infrastructure (V2I), to the extent it relates to safety[50]

We describe the agency's specific authority over these V2V-related items of motor vehicle equipment in more detail below.

1. Integrated OEM V2V technologies

Integrated OE V2V technologies, in this case, refer to all items of equipment that function as part of a V2V system and are built into the vehicle when it is produced for sale. As explained above, 49 U.S.C. § 30102(a)(7)(A) defines "motor vehicle equipment," in relevant part, as including all systems, parts, and components that are installed in or accompany a motor vehicle as it is originally manufactured. Again, "system, part, or component" is broad language that encompasses a large universe of items that can be considered motor vehicle equipment.[51]

---

[47] § 30102(a)(7)(B), if the equipment "improves" an already-existing function of the vehicle or is an "addition" to the vehicle.

[48] § 30102(a)(7)(B), if we interpret the equipment as constituting a motor vehicle "accessory" (something to be used while the vehicle is in operation, that enhances that operation), or § 30102(a)(7)(C), if we interpret the equipment as constituting a device used for the apparent purpose of traffic safety (purpose would be clearly observable from the characteristics of the object and the context of its use, rather than necessarily defined by the manufacturer's intent for the equipment).

[49] § 30102(a)(7)(B), because updates can be replacements, improvements.

[50] § 30102(a)(7)(B) and (C), if its apparent purpose is safety, it may be an "accessory" or a "device…manufactured…with the apparent purpose of safeguarding users of motor vehicles against accident, injury, or death." We note that there will certainly be roadside infrastructure that would not fall within this category. A stop sign, for example, may be provided by a municipality for safety reasons, and it may even be manufactured with the apparent purpose of safeguarding users of motor vehicles against accident, injury, or death, but NHTSA would not consider the stop sign to be motor vehicle equipment.

[51] As last accessed in Merriam Webster on Mar. 4, 2014: (1) A system is "a regularly interacting or interdependent group of items forming a unified whole . . . : a group of devices or artificial objects or an organization forming a network especially for distributing something or serving a common purpose." See www.merriam-webster.com/dictionary/system ; (2) A part is "one of the often indefinite or unequal subdivisions into which

The agency has already given some consideration to the application of subparagraph (A) of the definition of "motor vehicle equipment" to technologies that include both mechanical and electromechanical/tangible and intangible aspects. A recent example of such a technology that the agency has considered to be an item of motor vehicle equipment is the OnStar in-vehicle communications system.[52] OnStar is available on many new General Motors vehicles, and is also offered as an aftermarket option for certain other vehicles.[53] As an item that is built into the vehicle in a way that cannot easily be un-integrated, for the purposes of providing various functions such as emergency notification and turn-by-turn navigation, OnStar is considered by the agency to be a system, part, or component installed in motor vehicles as originally manufactured, when present on the vehicle prior to initial sale. Similarly, DSRC and other equipment that allow V2V-based safety applications to function would be considered "motor vehicle equipment" by virtue of these items being installed in a new motor vehicle at the time of manufacture, in the same manner as OnStar.

2. Integrated aftermarket equipment

The broad definition of "motor vehicle equipment" also covers equipment and devices purchased by motor vehicle users in the aftermarket, i.e., after the vehicle's initial sale.[54] The agency's jurisdiction over aftermarket equipment is important in regard to V2V-related technologies because consumers may be interested in obtaining equipment for their used vehicles to give them V2V capabilities and help them be seen by other vehicles on the roads. Further, any aftermarket software updates to V2V-related systems or software enabling other devices to connect to the V2V system would be considered "motor vehicle equipment" under this part of the definition, as discussed further below.

The statutory language in 49 U.S.C. § 30102(a)(7)(B) separates the items covered by this part of the definition into two groups: (1) those that are a "replacement or improvement," and (2) those that are an "accessory or addition." We note that even though these groups are different from the criteria that govern NHTSA's regulation of original motor vehicle equipment in § 30102(a)(7)(A), both statutory provisions essentially refer to "systems, parts, or components" – we interpret the additional terms in § 30102(a)(7)(B) simply as describing *when* the equipment becomes part of the vehicle (at some point after first sale, rather than prior to first sale). As all parts of a vehicle can need replacement, it does not seem accurate to consider the

---

something is or is regarded as divided and which together constitute the whole." See www.merriam-webster.com/dictionary/part?show=0&t=1366224315; and (3) A component is "a constituent part: INGREDIENT." See www.merriam-webster.com/dictionary/component.

[52] Letter from Anthony M. Cooke, Chief Counsel, NHTSA to Ashley G. Alley, Office of General Counsel, Government Accountability Office (Jul. 19, 2007). See http://isearch.nhtsa.gov/files/GAO%20telematics%20Sept%2013.htm (last accessed Jan. 27, 2014).

[53] See https://www.onstar.com/web/fmv/home?g=1 (last accessed Jan. 27, 2014).

[54] 49 U.S.C. § 30102(a)(7)(B) (covering replacements, improvements, accessories, and additions).

"replacements," "improvements," "accessories," or "additions" in part (B) as a narrower set of objects than in part (A). Thus, NHTSA interprets its authority over aftermarket equipment installed in used vehicles as at least as comprehensive as its authority over original equipment installed in new vehicles.

Items that are considered to be accessories or additions are not necessarily closely related to the systems, parts, and components originally installed in new motor vehicles (in the sense that these items potentially do not duplicate the functions of original equipment), as a "replacement" or "improvement" might be. The dictionary definition of "addition" seems to imply that an "addition" to the motor vehicle is an item that becomes united or joined with a motor vehicle.[55] In other words, it is not an item that can be freely carried into and out of the vehicle.

Section III.D.2 describes a wide range of aftermarket V2V equipment items that fall within NHTSA's authority to regulate. Integrated aftermarket V2V equipment is referred to in this document as a "retrofit safety device," and is defined as a V2V system purchased and installed in a vehicle after first sale, which can transmit and receive the BSM, run safety applications, and provide alerts/warnings to the driver through an in-vehicle display (likely the center console DVI). Another noteworthy feature of the RSD is its integration into the vehicle's data bus, so that it can obtain information from the vehicle about the vehicle's operation in use to maximize its effectiveness – such as having access to the vehicle's actual speed rather than attempting to estimate it through GPS coordinates, which helps determine the imminence of a potential crash event and could therefore improve timing for need to warn. Thus, the integrated aftermarket RSD is scarcely different from the integrated OE V2V system, with similar if not identical components, which can either "improve" the vehicle or be an "addition" to it under § 30102(a)(7)(B). Non-integrated aftermarket V2V equipment (i.e., that which can be removed from a vehicle relatively easily, like a navigation-system-type device or a smartphone application) will be covered in Section IV.A.3.

3. Non-integrated aftermarket equipment

It is difficult to predict at this point how wide the potential future range of aftermarket V2V equipment might be. If we take as an example all of the electronic tools that drivers now have at their disposal to aid in navigation, there are integrated OE services like GM's OnStar mentioned above, which is also available for certain vehicles as an aftermarket option; there are "dedicated" navigation devices sold by companies like Garmin or TomTom, which can be installed in a vehicle simply by mounting it in a cradle and can be as easily removed and

---

[55] As last accessed in Merriam Webster on Jan. 27, 2014: (1) An addition is "a part added (as to a building or residential section)." See www.merriam-webster.com/dictionary/addition; and (2) To add means "to join or unite so as to bring about an increase or improvement." See www.merriam-webster.com/dictionary/add.

installed in another vehicle; and there are smartphone applications, such as Google Navigation or Apple Maps, which use the phone's GPS (and often a connection to the Internet) to determine where a vehicle is and where it needs to go to reach a certain destination, all the while allowing full or nearly-full access to all of the phone's other features. It seems plausible that future aftermarket V2V devices will span a similar range of forms and functions. Depending on their design and apparent purpose, non-integrated or "nomadic" devices, which can be carried into and out of vehicles at the driver's whim, may still be covered by the Safety Act.

§ 30102(a)(7)(B) and (C) allow the agency to regulate "accessories" as well as "devices or articles ... manufactured [or] sold ... with the apparent purpose of safeguarding users of motor vehicles against risk of accident, injury, or death." As with the other portions of the definition of motor vehicle equipment, we interpret these words to cover both mechanical and electronic "accessories," "devices," and "articles."

The dictionary definition of "accessory" states that an accessory is a secondary item which adds some value or function (such as additional convenience or effectiveness) to the original item.[56] While such a definition does not contemplate that item's becoming a part of (or physically attached to) the motor vehicle in order to be regarded as an accessory (as such an interpretation would make "accessory" duplicative of the term "addition"), this definition does seem to imply some sort of use of the item in conjunction with the motor vehicle. Thus, an item could be an "accessory" under § 30102(a)(7)(B) if a substantial portion of its expected use were in conjunction with motor vehicles.

A dedicated handheld aftermarket V2V device would fall comfortably under any of these definitions – it could be an "accessory," or it could be a "device or article...manufactured or sold with the apparent purpose of safeguarding users of motor vehicles against risk of accident, injury, or death" because a substantial portion of its expected use is reasonably in conjunction with a motor vehicle. Moreover, the anticipated basic trait of any V2V device purchased for installation in a vehicle is that it emits the BSM, whether or however it provides safety information to the driver. Emitting a BSM will necessarily protect the driver from incidents that might occur with other V2V-equipped vehicles, which are able to detect the BSM and alert their own drivers accordingly. This is fundamentally a safety purpose.

For mobile devices, like a smartphone, a tablet, a tablet computer or other mobile platform, in which V2V-enabled applications and related technology are only one of several functions, the Safety Act authorizes the agency to regulate the V2V-enabled applications to the extent that they are an accessory to a motor vehicle or that they are "manufactured or sold with

[56] As last accessed in Merriam Webster on Jan. 27, 2014: (1) An accessory can be "a thing of secondary or subordinate importance: ADJUNCT" or "an object or device not essential in itself but adding to the beauty, convenience, or effectiveness of something else." See www.merriam-webster.com/dictionary/accessory.

the apparent purpose of safeguarding users of motor vehicles against risk of accident, injury, or death."[57] Consider the example of an application that a vehicle owner can download for a smartphone to enable the smartphone to transmit and receive BSMs. This application on the smartphone could gather information on surrounding vehicles that are transmitting BSMs and use this information to alert a driver of a potential crash. In this situation, the application is an accessory to the motor vehicle (by way of its use with the motor vehicle) and also a "device or article manufactured or sold with the apparent purpose of safeguarding users of motor vehicles against risk of accident, injury, or death."

In addition to the software application itself, the performance of safety applications could be affected by characteristics of the mobile platform (i.e., hardware) on which they are run. Hardware attributes such as data processing speed, GPS accuracy, screen size, contrast ratio, image resolution, camera resolution, and sound/voice quality could affect the application's ability to perform its safety function. For example, the processor on the mobile platform might not have the necessary computational power to process incoming BSMs quickly enough so that a warning could be issued to the driver in a timely manner. This possibility could be taken into account by establishing criteria for the application to ensure that it could be run only on devices with sufficient technical hardware capability to enable the application to function at a level of minimum performance necessary for safety.

The aftermarket V2V device designs examined in this paper that are most likely related to future nomadic aftermarket V2V devices include "self-contained" devices, which we assume would connect to the vehicle only for a power source (i.e., not connect to the data bus) and would both emit/receive a BSM and provide safety applications for the driver, and "vehicle awareness devices" or VADs, which simply emit a BSM. Both of these types of devices are discussed in more detail in Section III.D.2, and as explained above, fall comfortably within the definition of motor vehicle equipment under the Safety Act.

4. Software that aids or updates the V2V system

We discussed above that NHTSA's Safety Act authority covered not only tangible mechanical and electronic motor vehicle equipment, but also reasonably extended to cover *intangible* electronic motor vehicle equipment. Depending on their character, software and algorithms that aid or update V2V technologies may be OE, and thus covered under § 30102(a)(7)(A); or those that are part of aftermarket devices or are updates to either OE or

---

[57] The agency notes that its regulatory authority with respect to mobile devices extends beyond V2V applications and technologies. Examples of more general capabilities or features that may cause mobile devices, insofar as they are used in conjunction with motor vehicles, to fall within the ambit of "motor vehicle equipment" include the following: the capability of being paired with a vehicle's electronics, whether through wired or wireless connection; the "driver mode" on unpaired devices; and the capability of the devices and the vehicle to distinguish automatically whether a device is located in the driver's position or a passenger's position.

aftermarket devices, may be covered under § 30102(a)(7)(B) as "replacements," "improvements," or "additions." Software could also be an "accessory" as long as a substantial portion of its expected use is in conjunction with a motor vehicle. For example, a software application that could be installed on a cell phone for the purpose of enabling the phone user to perform such vehicle-related functions as starting/stopping or locking/unlocking a motor vehicle through manipulating the controls on the phone would be considered an accessory to the motor vehicle even if the cell phone itself is not.[58] Other applications can perform functions related to on-road vehicle operation. An example is a software application that uses the camera function on a smartphone placed on a vehicle's dashboard to detect and recognize vehicles on the road ahead and provide forward collision warnings.[59] Regardless of where the software is located (i.e., on what type of hardware), the software itself would be subject to the Safety Act and could be subject to a safety standard or other exercise of NHTSA's authority (e.g., a recall for a defective condition).

5. Roadside infrastructure (V2I)

There are a couple of types of roadside infrastructure that may be involved in facilitating DSRC-based V2V, as discussed in Section III.D.3. Communications infrastructure physically helps get the messages from the vehicles to and from the SCMS (as at first usage, when the

---

[58] Our conclusion that software can be an item of motor vehicle equipment is reinforced by the recent enactment of MAP-21. In that Act, Congress implicitly recognized this fact when it directed NHTSA to examine the need for safety standards with regard to electronic systems in passenger motor vehicles. See Pub. L. No. 112-141, §§ 31401-02, 126 Stat. 405.
Separately, NHTSA is not the only agency that has concluded its statutory authority applies to software. For example, the Food and Drug Administration (FDA) has adopted an interpretation of its statutory authority that would subject software installed on mobile devices to regulation under the Federal Food, Drug, and Cosmetic Act, 21 U.S.C. §§ 301 et eq. (2006). See Guidance for Industry and Food and Drug Administration Staff; Mobile Medical Applications; Availability, 78 Fed. Reg. 59038 (Sept. 25, 2013) [hereinafter FDA Guidance] (announcing the availability of the FDA's application of the agency's regulatory authority to software applications installed on mobile devices) at www.fda.gov/downloads/MedicalDevices/../UCM263366.pdf (last accessed Feb. 6, 2014). The FDA stated that it was issuing the guidance to inform manufacturers, distributors, and other entities about how the FDA intends to apply its regulatory authorities to select software applications intended for use on mobile platforms (mobile applications or "mobile apps"): Consistent with the FDA's existing oversight approach that considers functionality rather than platform, the FDA intends to apply its regulatory oversight to only those mobile apps that are medical devices and whose functionality could pose a risk to a patient's safety if the mobile app were to not function as intended. FDA Guidance, *supra*. The term "device" is defined in the Federal Food, Drug, and Cosmetic Act as:

> an instrument, apparatus, implement, machine, contrivance, implant, in vitro reagent, or other similar or related article, including any component, part, or accessory, which is . . . recognized in the official National Formulary, or the United States Pharmacopeia, or any supplement to them, [ ] intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation, treatment, or prevention of disease, in man or other animals, and which does not achieve its primary intended purposes through chemical action within or on the body of man or other animals and which is not dependent upon being metabolized for the achievement of its primary Intended purpose.

21 U.S.C. § 321(h) (2006).
[59] *E.g.*, see www.ionroad.com/ (last accessed Jan. 28, 2014).

vehicle is self-reporting a malfunction, or when it is reporting on another vehicle's perceived malfunction), and helps get new certificates and the CRL from the SCMS to the V2V-equipped fleet. The communications infrastructure includes roadside equipment (RSE) units, which contain a DSRC radio or a cellular modem, a processor, connection ports, antennas, and software. The RSE uses wireless DSRC to send messages/materials to on-board equipment (OBE). The RSE also connects to the SCMS via a wired connection (i.e., through the Internet), in order to support the transmission of reports from OBE through the RSE to the SCMS and the transmission of certificates from the SCMS through the RSE to the OBE. Security infrastructure helps ensure that the messages sent are trustworthy, and helps remove malfunctioning devices from the system and protect against outside threats. Physically speaking, security infrastructure will include computer hardware, software, and a physical location for all of the components of the SCMS, which will be connected via the Internet to the RSEs, which then connect to the V2V-equipped vehicles' OBE.

It could, therefore, end up being important for NHTSA to regulate some aspects of infrastructure as a way to avoid regulatory gaps that could critically compromise the overall system. Given that certain elements of infrastructure are just as related to safety as on-board equipment, and equally intended for safety, the next question becomes *how*, if possible, to regulate that infrastructure. Fitting these infrastructure pieces under NHTSA's Safety Act authority as items of motor vehicle equipment depends on their nature and apparent purpose. If, as discussed above, we consider "accessories" as items that are used concurrently with one vehicle, then many pieces of roadside infrastructure, which can be used concurrently with many vehicles at once, are probably not "accessories." However, if the apparent purpose of the roadside equipment is safety, then it is arguably a device "manufactured … with the apparent purpose of safeguarding users of motor vehicles against risk of accident, injury, or death," and therefore motor vehicle equipment under § 30102(a) (7)(C). For example, an RSE at an intersection could provide Signal Phase and Timing information and an intersection map to vehicle OBE to support the safety applications that might be triggered to help drivers avoid intersection collisions; this would arguably be a safety purpose, even if the RSE could also be providing that SPaT information and map for other purposes as well. For that matter, any RSE that communicates with vehicles in a way that promotes V2V or V2I communications would potentially appear to be doing so for a safety purpose. On the other hand, an RSE that might receive data from a vehicle, but cannot communicate with vehicles, would be unlikely to affect vehicle safety and, accordingly, would likely not be considered motor vehicle equipment.

Policy Need IV-1 Road Side Equipment Authority

Policy Need:	Determination of Authority for NHTSA to regulate Road Side Equipment
Description:	NHTSA will thoroughly evaluate the need to regulate aspects of RSE operation and assess its authority for doing so.

Even if NHTSA decided not to exercise authority directly over roadside infrastructure, NHTSA can still significantly influence its design and operation through our Safety Act authority to establish safety standards. As will be discussed in more detail below when we explain what a V2V system practicable and consistent with our legal authority might include, the Safety Act states, among other things, that motor vehicle safety standards must be: (1) practicable, (2) meet the need for motor vehicle safety, and (3) be stated in objective terms.[60] As one hypothetical example, in order to meet the need for motor vehicle safety, a safety standard for DSRC-enabled FCW might include provisions to ensure that all messages received from other vehicles that could trigger the FCW: (1) Come with some kind of authentication to verify message is from a trusted source; and (2) Include provisions covering checking the accuracy of the information from the outside source. RSE would need to be interoperable in order to ensure that they functioned correctly within the system – meaning that the messages they send have to be able to be read by the OBE in order for the OBE to act on it.

Many aspects of the V2V system, then, can qualify as motor vehicle equipment under the Safety Act, which means that NHTSA can regulate them and mandate their installation in new motor vehicles (as appropriate) per 49 U.S.C. § 30111 (NHTSA may prescribe motor vehicle safety standards for motor vehicles and motor vehicle equipment) and § 30102(a)(9) ("motor vehicle safety standard" means a minimum standard for motor vehicle or motor vehicle equipment performance). For the other parts of the V2V system that NHTSA cannot regulate directly under the Safety Act, we can influence how they develop to a significant extent through the manner in which we regulate, as in the infrastructure example above.

Under both the Vehicle Safety Act and the Highway Safety Act, NHTSA has other ways of affecting the parts of the V2V system that cannot be regulated directly. For example, 49 U.S.C. § 30182 provides NHTSA authority to enter into contracts, grants, and cooperative agreements with a wide range of outside entities to conduct motor vehicle safety research and development activities, including activities related to new and emerging technologies. Separately, the Highway Safety Act (23 U.S.C. § 401 et seq.) authorizes NHTSA to enter into contracts, grants, cooperative agreements, and other transactions for research and development activities with a similarly wide range of outside entities in "all aspects of highway and traffic safety systems … relating to [ ] vehicle, highway, [and] driver … characteristics" (§ 403(b)), as well as collaborative research and development, on a cost-shared basis, to "encourage innovative solutions to highway safety problems" and "stimulate the marketing of new highway safety related technology by private industry" (§ 403(c)). Because issues related to V2V are cross-cutting, spanning both the Vehicle Safety Act and the Highway Safety Act, these separate authorities provide the agency with sufficient flexibility to enter into a variety of agreements

[60] 49 U.S.C. § 30111(a).

related to the development of a V2V security system (although the agency currently lacks sufficient appropriations to incur any significant Federal expenditures for these purposes).

A principle of appropriations law known as the "necessary expense doctrine" allows NHTSA to take the next step of entering into contracts or agreements to ensure the existence of sufficient communications and security systems to support deployment of V2V technologies, if V2V communications are mandated or otherwise regulated by a Federal Motor Vehicle Safety Standard or other NHTSA regulation. According to that principle, when an appropriation is made for a particular purpose, it confers on the receiving agency the authority to incur expenses necessary to carry out the purpose of the appropriation.[61] Under the necessary expense doctrine, the spending agency has reasonable discretion to determine what actions are necessary to carry out the authorized agency function. Here, the deployment and operation of the SCMS is necessary in order for V2V technology and on-board equipment to function in a safe, secure and privacy-protective manner. As designed, V2V technology cannot operate without a sufficient security system, and absent such a security system, misbehavior by hackers or others could compromise V2V functionality and participant privacy. If the problem of "misbehavior" were sufficiently widespread, it might even cause widespread disregard of or delayed response to V2V warnings. Hence, a robust SCMS is imperative in the V2V regulatory environment.

For these reasons, in addition to NHTSA's research, development, and collaboration authority under the Vehicle Safety Act and the Highway Safety Act, if the agency issues a V2V FMVSS or other V2V-related regulation, the necessary expense doctrine provides sufficient authority under the Vehicle Safety Act to take the next step of entering into agreements or contracts, either for cost or no-cost, with the goal of ensuring the existence (i.e., the development and operation) of sufficient communications and security systems to support the reliability and trustworthiness of V2V communications. As is the case under the agency's research and development authority, discussed above, the current limiting factor is the absence of sufficient appropriations to incur any significant expenses in this regard.

---

[61] Under the necessary expense doctrine, an expenditure is justified if it meets a three-part test: (1) the expenditure must bear a logical relationship to the appropriation sought to be charged (i.e., it must make a direct contribution to carrying out either a specific appropriation or an authorized agency function for which more general appropriations are available); (2) the expenditure must not be prohibited by law; and (3) the expenditure must not be otherwise provided for (i.e., it must not be an item that falls within the scope of some other appropriation or statutory funding scheme. See U.S. Gen. Accounting Office, Principles of Federal Appropriations Law 4–22 (3d ed.2004) (the "GAO Redbook") at www.gao.gov/special.pubs/3rdeditionvol1.pdf.

B. Agency actions that are practicable and consistent With its legal authority

1. Elements of the Safety Act that would apply to potential future agency actions

A V2V system, as currently envisioned, is a compilation of many elements. Essentially, DSRC units in vehicles send out BSMs to alert other vehicles to their presence and receive BSMs from other vehicles in order to determine whether to warn their drivers of impending risk; BSMs must be accompanied by security certificates so that the receiving vehicle can trust their source; and the receiving vehicle receives the BSM through its DSRC unit and triggers safety applications (at this point, we are only discussing applications that would provide warnings), if necessary, depending on what the message received indicates about the sending vehicle's behavior. In order for the entire system to function effectively, each vehicle or aftermarket device participating in the system may need periodic updates to its security certificates, and may need information about vehicles or devices that are malfunctioning or have been otherwise compromised (so that they know not to trust the BSMs received from those vehicles or devices). In addition, the system also needs: (1) An overarching security manager to provide those updates and that information; and (2) A communications network to get those updates and information to the devices. How, then, would NHTSA exercise its legal authority from a central source to bring these elements into existence?

As explained above, NHTSA may establish Federal Motor Vehicle Safety Standards (which would be codified in 49 CFR Part 571) for new motor vehicles and motor vehicle equipment. NHTSA could establish FMVSSs for DSRC units in vehicles (requiring that all new vehicles be equipped with DSRC) and in aftermarket equipment, and also for the safety applications enabled by those DSRC units. As part of those FMVSSs, NHTSA could include requirements for content of the BSM, content of the security certificates (including how up-to-date they need to be), and so on.

NHTSA has general authority to prescribe regulations that help to carry out the duties and the powers of the Secretary, including, for example, the overarching purpose of 49 U.S.C. Chapter 301, to reduce traffic accidents and deaths and injuries resulting from traffic accidents.[62] There are fewer substantive requirements for a non-FMVSS regulation,[63] which can be helpful,

---

[62] Under the Safety Act as originally written, NHTSA had express authority to issue, amend, and revoke such rules and regulations as deemed necessary to carry out the Safety Act. See Safety Act, Sec. 119, previously codified at 15 U.S.C. § 1407. That language was not included in the recodification of the Safety Act in 1994, but the Department of Transportation Act continues to include similar language, currently codified at 49 U.S.C. § 322, giving the Secretary authority to prescribe regulations to carry out the duties and powers of the Secretary, and allowing that authority to be delegated.

[63] A regulation not promulgated as an FMVSS must still comply with Administrative Procedure Act requirements to be reasonable and contain a rational connection between the factual support for the rule and the requirements of the

for example, if the agency is concerned about fulfilling one or some of the requirements discussed below for FMVSSs; but the agency also has more enforcement tools available for dealing with non-compliance with a safety standard as compared to non-compliance with a non-FMVSS regulation.[64] Additionally, the preemptive effect of an FMVSS is clear from the Safety Act.[65]

We will concentrate the rest of this discussion on the requirements for FMVSSs. A future V2V program would likely be more comprehensively successful if DSRC and DSRC-based safety applications are required through FMVSSs than if NHTSA issued non-FMVSS regulations that merely set out how DSRC must work if provided. Without a requirement that all new vehicles be equipped with DSRC, it would likely take far longer for DSRC to penetrate a substantial portion of the nation's vehicle fleet, thus delaying V2V's benefits and making security system needs hard to predict.

Under the Safety Act, NHTSA's motor vehicle safety standards are generally performance-oriented.[66] Further, the standards are required to be practicable, objective, and meet the need for safety.[67] The following section will discuss briefly the meaning of each of these requirements, and then explore what the agency might do in order to ensure that safety standards for DSRC and DSRC-enabled safety applications reasonably meet those requirements.

a) What does "performance-oriented" mean?

In the Safety Act, the Secretary is directed to issue motor vehicle safety standards. "Motor vehicle safety standards" are defined as "minimum standard[s] for motor vehicle or motor vehicle equipment *performance*."[68] One point to note at the outset is the party of whom performance is required: NHTSA's safety standards apply to manufacturers of new motor

---

rule itself, and it must also carry out the powers and duties of the Secretary, by doing things like facilitating the agency's performance of its statutory functions or providing additional assurance that regulated parties will properly perform their statutory and regulatory obligations.

[64] NHTSA generally has three enforcement tools relevant to standards and regulations: notification and remedy (recalls) of noncompliant vehicles (49 U.S.C. §§ 30118, 30119, 30120), injunctions (49 U.S.C. § 30163(a)), and civil penalties (49 U.S.C. § 30165). While NHTSA can order recalls and assess civil penalties, only a court can order an injunction; additionally, NHTSA's orders for recalls or civil penalty assessments are themselves enforceable only in court.

[65] 49 U.S.C. § 30103(b).

[66] 49 U.S.C. § 30102(a)(8) (defining "motor vehicle safety" as "the performance of a motor vehicle . . . in a way that protects the public against unreasonable risk of accidents occurring because of the design, construction, or performance of a motor vehicle"); *and* § 30102(a)(9) (defining "motor vehicle safety standard" as "a minimum standard for motor vehicle or motor vehicle equipment performance"). See also: S. Rep. No. 89-1301, at 2713-14 (1966) (stating that motor vehicle standards issued by NHTSA should specify a minimum level of safety performance).

[67] 49 U.S.C. § 30111(a) (establishing requirements for NHTSA to follow when issuing motor vehicle safety standards).

[68] Id.; see also: § 30102(a)(9) (emphasis added).

vehicles and motor vehicle equipment. It therefore falls to those "manufacturers" – from vehicle OEMs to OE suppliers to aftermarket device manufacturers to creators of V2V safety applications for smartphones – to certify compliance with any safety standards established by NHTSA, and to conduct recalls and remedy defects if NHTSA finds them.[69] Vehicle owners are generally not required to comply with NHTSA's safety standards, which means that for vehicles already on the roads, participation in the V2V system would be entirely voluntary: NHTSA can regulate how aftermarket devices function, but it cannot force manufacturers or drivers to add them to used vehicles. The one exception to this rule against retrofit is that NHTSA has authority to require retrofit of commercial heavy-duty vehicles,[70] but that is not part of this research paper on light-duty vehicles, and will be examined in more detail in the agency's decision in 2014 with reference to heavy-duty vehicles.

While NHTSA is directed to establish performance standards, the case law and the legislative history indicate that when necessary to promote safety, NHTSA can be quite specific in drafting its performance standards and may require or preclude the installation of certain equipment. The cases have reinforced this concept by determining that NHTSA is "generally charged"[71] with setting performance standards, instead of becoming directly involved in questions of design.[72] The legislative history further illustrates that NHTSA's standards are to "[specify] the required minimum safe performance of vehicles but not the manner in which the manufacturer is to achieve the specified performance."[73] An example cited in the legislative history points to "a building code which specifies the minimum load-carrying characteristics of the structural members of a building wall, but leaves the builder free to choose his own materials and design."[74] In that example, the agency could require the wall to be built (analogous to requiring certain equipment in vehicles) but would be expected to measure the wall's regulatory compliance by its performance rather than its design.

Although the Safety Act directs NHTSA to issue performance standards, however, Congress understood that the agency may preclude certain designs through these performance standards. "Motor vehicle safety" is defined in the Safety Act as the performance of a motor

---

[69] 49 U.S.C. § 30115(a), "Certification of compliance; In general"; § 30116, "Defects and noncompliance found before sale to purchaser"; § 30117(a), "Providing information to, and maintaining records on, purchasers; Providing information and notice"; § 30118, "Notification of defects and noncompliance"; § 30119, "Notification procedures"; § 30120, "Remedies for defects and noncompliance."
[70] Per 49 CFR 1.95, which delegates to NHTSA the Secretary's authority under Sec. 101(f) of the Motor Carrier Safety Improvement Act of 1999 (Pub. L. 106-159; Dec. 9, 1999) to promulgate safety standards for "commercial motor vehicles and equipment subsequent to initial manufacture." NHTSA's retrofit authority is coextensive with FMCSA's.
[71] *Washington v. Dept. of Transp.*, 84 F.3d 1222, 1224 (10th Cir. 1996) (citations omitted).
[72] Id. at 1224 (citations omitted).
[73] S. Rep. No. 89-1301, at 2713-14 (1966).
[74] Id.

vehicle in a way that protects the public from unreasonable risks of accident due to (among other things) the design of a motor vehicle.[75] The legislative history indicates that this language is not intended to afford the agency the authority to promulgate design standards, "but merely to clarify that the public is to be protected from inherently dangerous designs which conflict with the concept of motor vehicle safety."[76] This clarification is evidence that Congress recognized that performance standards inevitably have an impact on the design of a motor vehicle.[77]

The courts have further elaborated on the framework established by Congress and have recognized that, when necessary to achieve a safety purpose, NHTSA can be quite specific in establishing performance standards even if certain designs will be precluded. For example, the Sixth Circuit found that an agency provision permitting rectangular headlamps, but only if they were of certain specified dimensions, was not an invalid design restriction and "serve[d] to ensure proper headlamp performance," reasoning that "the overall safety and reliability of a headlamp system depends to a certain extent upon the wide availability of replacement lamps, which in turn depends upon standardization."[78] Thus, the court found it permissible for the agency to establish very specific requirements for headlamps even though it would restrict design flexibility.[79]

Further, the cases indicate that NHTSA can establish standards to require the installation of certain specific equipment on vehicles and establish performance standards for that equipment. For example, the Tenth Circuit found in *Washington v. DOT* that "NHTSA's regulatory authority extends beyond the performance of motor vehicles *per se*, to particular items of equipment."[80] In that case, the validity of NHTSA's FMVSS No. 121 requiring ABS systems on air-braked vehicles was challenged as "imposing design specifications rather than performance criteria."[81] The court's conclusion was based not only on the fact that prior courts had upheld NHTSA's standards requiring particular equipment,[82] but also on the fact that

---

[75] § 30102(a)(9).
[76] H.R. Rep. No. 89-1919, at 2732 (1966).
[77] Courts have also recognized this fact. See *Chrysler Corp. v. Dept. of Transp.*, 515 F.2d 1053, 1058-59 (6th Cir. 1975); see also: Washington, 84 F.3d at 1224 (stating "the performance-design distinction is much easier to state in the abstract than to apply definitively-so ..... This is particularly true when, due to contingent relationships between performance requirements and design options, specification of the former effectively entails, or severely constrains, the latter.").
[78] Chrysler Corp., 515 F.2d at 1058-59.
[79] Id.
[80] Washington, 84 F.3d at 1222, 1225 (citations omitted).
[81] Id. at 1223.
[82] Id. at 1225 (citing *Chrysler Corp. v. Rhodes*, 416 F.2d 319, 322, 322 n. 4) (1st Cir. 1969) ("motor vehicles are required to have specific items of equipment . . . These enumerated items of equipment are subject to specific performance standards," including lamps and reflective devices requiring "specific items of equipment")); *Wood v. Gen. Motors Corp.*, 865 F.2d 395, 417 (1st Cir. 1988) ("requiring seat belts or passive restraints . . . has elements of

Congress had recognized NHTSA's former rulemakings and left NHTSA's authority unchanged when it codified the Safety Act in 1994.

Thus, in summary, NHTSA is required to issue performance standards when regulating motor vehicles and motor vehicle equipment. However, NHTSA is able to be quite specific in establishing performance standards and may preclude certain designs that are contrary to the interests of safety. Further, NHTSA may require the installation of certain equipment and establish performance standards for that equipment.

b) Standards "meeting the need for motor vehicle safety"

As required by the Safety Act, standards issued by the agency must "meet the need for motor vehicle safety."[83] As "motor vehicle safety" is defined in the statute as protecting the public against "unreasonable risk" of accidents, death, or injury,[84] the case law indicates that there must be a nexus between the safety problem and the standard.[85]

However, a standard need not address safety by direct means. In upholding NHTSA's authority to issue a safety standard requiring standardized vehicle identification numbers, the Fourth Circuit Court of Appeals found that an FMVSS requiring VINs met the need for motor vehicle safety by such indirect means as reducing errors in compiling statistical data on motor vehicle crashes (in order to aid research to understand current safety problems and support future standards, to increase the efficiency of vehicle recall campaigns, and to assist in tracing stolen vehicles).[86]

c) "Objective" standards

A standard is objective if it specifies test procedures that are "capable of producing identical results when test conditions are exactly duplicated" and performance requirements whose satisfaction is "based upon the readings obtained from measuring instruments as opposed to subjective opinions."[87] The requirement that standards be stated in objective terms matches

---

a design standard"); Automotive Parts & Accessories Ass'n v. Boyd, 407 F.2d 330, 332 (D.C. Cir. 1968) ("factor equipped . . . head restraints which meet specific Federal standards").

[83] 49 U.S.C. § 30111(a).

[84] 49 U.S.C. § 30102(a)(8).

[85] e.g.,: *National Tire Dealers Ass'n v. Brinegar*, 491 F.2d 31, 35-37 (D.C. Cir. 1974) (stating that the administrative record did not support a significant nexus between motor vehicle safety and requiring retread tires to have permanent labels because there was no showing that a second-hand owner would be dependent on these labels and no showing as to how often such situations would arise); See also *H&H Tire Co. v. Dept. of Transp.*, 471 F.2d 350, 354-55 (7th Cir. 1972) (expressing doubt that the standard met the need for safety because there was little evidence that the required compliance tests would ensure that retreaded tires would be capable of performing safely under modern driving conditions).

[86] *Vehicle Equip. Safety Comm'n v. NHTSA*, 611 F.2d 53, 54 (4th Cir. 1979).

[87] *Chrysler Corp. v. Dept. of Transp.*, 472 F.2d 659, 676. See also *Paccar, Inc., v. Nat'l Highway Traffic Safety Admin.*, 573 F.2d 632, 644 (9th Cir. 1978).

the overall statutory scheme requiring that manufacturers self-certify that their motor vehicles or motor vehicle equipment comply with the relevant FMVSSs.[88] In order for this statutory scheme to work, the agency and the manufacturer must be able to obtain the same result from identical tests in order to objectively determine the validity of the manufacturer's certification.[89]

Using those two elements of objectivity (capable of producing identical results and compliance based on measurements rather than subjective opinion), the Sixth Circuit Court of Appeals found that the test procedure in question in an early version of FMVSS No. 208 was not objective because the test dummy specified in the standard for use in compliance testing did not give consistent and repeatable results.[90] The court in this case was unconvinced that the standard met the objectivity requirements even though NHTSA based its test procedure on a test dummy in a voluntary automotive industry standard (Society of Automotive Engineers Recommended Practice J963). The court rejected NHTSA's explanation that, although J963 "may not provide totally reproducible results," "dummies conforming to the SAE specifications are the most complete and satisfactory ones presently available."[91] Further, the court rejected NHTSA's reasoning that, in the event that the agency's test results were different from those of the manufacturers because of the difference in the test dummies, NHTSA's test results would not be used to find non-compliance, stating that "there is no room for an [ ] agency investigation [ ] in this procedure" that enable the agency to compare results of differing tests.[92]

Other courts have also reached similar conclusions. The Ninth Circuit Court of Appeals, relying on the same reasoning adopted by the Sixth Circuit, found that a compliance road test specifying the use of surfaces specifically rated with quantifiable numbers (defining the "slickness" of the surfaces) was objective despite "[t]he fact that it is difficult to create and thereafter maintain a road surface with a particular coefficient of friction does not render the

---

[88] 49 U.S.C. § 30115(a).
[89] Chrysler Corp., 472 F.2d at 675.
[90] As the court stated,

> The record supports the conclusions that the test procedures and the test device specified . . . are not objective in at least the following respects: (1) the absence of an adequate flexibility criteria for the dummy's neck; the existing specifications permit the neck to be very stiff, or very flexible, or somewhere in between, significantly affecting the resultant forces measured on the dummy's head. (2) Permissible variations in the test procedure for determining thorax dynamic spring rate (force deflection characteristics on the dummy's chest) permit considerable latitude in chest construction which could produce wide variations in maximum chest deceleration between two different dummies, each of which meets the literal requirements of SAE J963. (3) The absence of specific, objective specifications for construction of the dummy's head permits significant variation in forces imparted to the accelerometer by which performance is to be measured.

Id. at 676-78.
[91] Id. at 677.
[92] Id. at 677-79.

specified coefficient any less objective."[93] In this case, both NHTSA and the manufacturer would perform road tests on surfaces with identically rated friction coefficients.[94] In a later case, the Sixth Circuit upheld NHTSA's decision not to incorporate a test suggested by a commenter for wheelchair crashworthiness performed with a "test seat" that "shall be capable of resisting significant deformation" during a test as not sufficiently objective.[95] In the absence of language quantifying how much deformation is significant, terms such as "significant deformation" do not provide enough specificity to remove the subjective element from the compliance determination process.

d) "Practicable" standards

In general, the practicability of a given standard involves a number of considerations. The majority of issues concerning the practicability of a standard arise out of whether the standard is technologically and economically feasible. An additional issue is whether the means used by manufacturers to comply with a standard will be accepted and correctly used by the public.

e) "Technologically practicable" standards

Significant technical uncertainties in meeting a standard might lead a court to find that a standard is not practicable. For example, the Sixth Circuit Court of Appeals upheld NHTSA's decision to amend FMVSS No. 222 to include requirements for wheelchair securement and occupant restraint on school buses with a static[96] compliance test instead of a dynamic test,[97] noting that the administrative record showed that this particular dynamic test was underdeveloped and had many unresolved technical problems.[98] The court noted that it is not

---

[93] *Paccar, Inc. v. Nat'l Highway Traffic Safety Admin.*, 573 F.2d 632, 644 (9th Cir. 1978), *cert. denied*, 439 U.S. 862 (1978).

[94] Id. (stating that the "skid number method of testing braking capacity meets the [objectivity] definition. Identical results will ensue when test conditions are exactly duplicated. The procedure is rational and decisively demonstrable. Compliance is based on objective measures of stopping distances rather than on the subjective opinions of human beings.").

[95] *Simms v. Nat'l Highway Traffic Safety Admin.*, 45 F.3d 999, 1007-08 (6th Cir. 1995).

[96] Static testing tests the strength of individual components of the wheelchair separately, while dynamic testing subjects the entire wheelchair to simulated real-world crash conditions. See *Simms*, 45 F.3d at 1001.

[97] Id. at 1006-08. Petitioners argued that NHTSA had acted unlawfully in promulgating standards for the securement of wheelchairs on school buses based only on "static" instead of "dynamic" testing. Id. Static testing tests the strength of the individual components of a securement device. Id. Dynamic testing is a full systems approach that measures the forces experienced by a human surrogate (test dummy) in a simulated crash that replicates real-world conditions and assesses the combined performance of the vehicle and the securement device. Id.

[98] Id. at 1005-07. NHTSA agreed that dynamic testing is the preferred approach (because it more fully and accurately represents the real-world conditions in which the desired safety performance is to be provided), but explained that it was not practicable at that time to adopt dynamic testing because there was:

> (1) [N]eed to develop an appropriate test dummy; (2) need to identify human tolerance levels for a handicapped child; (3) need to establish test conditions; (4) need to select a "standard" or surrogate wheelchair; (5) need to establish procedures for placing the wheelchair and test dummy in an effective test

practicable "[t]o attempt to fashion rules in an area in which many technical problems have been identified and no consensus exists for their resolution .... ."[99] In another example, the Ninth Circuit Court of Appeals found a compliance test procedure using a specified friction (slickness) coefficient to be impracticable due to technical difficulties in maintaining the specific slickness test condition. As mentioned above, the Ninth Circuit found the specified coefficient test condition to be objective.[100] However, simply being objective did not also make the test condition practicable. Thus, the cases show that when significant technical uncertainties and difficulties exist in a standard promulgated by NHTSA, those portions of the standard can be considered impracticable under the Safety Act.

However, the requirement that a standard be technologically feasible does not include the additional requirement that the agency show that the technology to be used to comply with the standard is already fully developed and tested at the time that the standard is promulgated. The Sixth Circuit upheld a NHTSA standard requiring "Complete Passive Protection," that required the installation of airbags as standard equipment, by a future date, rejecting petitioner's contention that NHTSA may only establish performance requirements which can be met with devices which, at the time of the rulemaking, are developed to the point that they may be readily installed.[101] Relying on the legislative history of the Safety Act, the court found that the agency "is empowered to issue safety standards which require improvements in existing technology or which require the development of new technology, and is not limited to issuing standards based fully on devices already developed."[102] Thus, the requirement that standards be technologically feasible is sufficiently broad that it can be satisfied by showing that new technology can be developed in time to comply with the effective date of the standard. A corollary of the agency's authority to issue technology-driving standards is that the agency can rely on data other than

---

> condition; and (6) need to develop an appropriate test buck to represent a portion of the school bus body for securement and anchorages.
>
> Id. at 1005.

[99] Id. at 1010-11.

[100] *Paccar, Inc. v. Nat'l Highway Traffic Safety Admin.*, 573 F.2d 632, 644 (9th Cir. 1978).

[101] See *Chrysler Corp. v. Dept. of Transp.*, 472 F.2d 659, 666, 671-75 (6th Cir. 1972). Stages one and two required vehicle manufacturers to provide "Complete Passive Protection" or one of two other options on vehicles manufactured between January 1, 1972 and August 14, 1973 (for stage one) and after August 15, 1973 (stage two). See id. at 666-67. Stage three, requiring solely "Complete Passive Protection," was required by August 15, 1975. Id. at 667.

[102] Id. at 673. In making its decision, the court stated

> [I]t is clear from the Act and its legislative history that the Agency may issue standards requiring future levels of motor vehicle performance which manufacturers could not meet unless they diverted more of the ir resources to producing additional safety technology than they might otherwise do. This distinction is one committed to the Agency's discretion, and any hardships which might result from the adoption of a standard requiring . . . a great degree of developmental research, can be ameliorated by the Agency under . . . The section [that] allows the Secretary to extend the effective date beyond the usual statutory maximum of one year from the date of issuance, as he has done [here].

Id. at 673.

real-world crash data in justifying those standards. Technology that is not yet either fully developed or being installed on production vehicles cannot generate real-world performance data. Thus, in justifying the issuance of technology-driving standards, it is permissible, even necessary, for the agency to rely on analyses using experimental test data or other types of non-real world performance information in determining whether such standards "meet the need for vehicle safety."

f) "Economically practicable" standards

A standard can be considered impracticable by the courts due to economic infeasibility. This consideration primarily involves the costs imposed by a standard.[103] In the instances in which a court has been called upon to assess whether a standard is economically feasible, typically with respect to an industry composed largely of relatively small businesses, the courts have asked whether or not the cost would be so prohibitive that it could cause significant harm to a well-established industry. In essence, this consideration generally establishes a non-quantified outer limit of the costs that can be reasonably imposed on regulated entities. If compliance with the standard is so burdensome, i.e., costly, so as to create a significant harm to a well-established industry, courts have generally found that the standard is impracticable in its application to that industry.

g) Standards that encourage "public acceptance and use"

Finally, a standard might not be considered practicable if the public were not expected to accept and correctly use the technologies installed in compliance with the standard. When considering passive restraints such as automatic seatbelts, the D.C. Circuit stated that "the agency cannot fulfill its statutory responsibility [in regard to practicability] unless it considers popular reaction."[104] While the agency argued in that case that public acceptance is not one of the statutory criteria that the agency must apply, the court disagreed. The court reasoned that "without public cooperation there can be no assurance that a safety system can 'meet the need for motor vehicle safety.'"[105] Thus, as a part of the agency's considerations, a standard issued by the agency will not be considered practicable if the technologies installed pursuant to the standard are so unpopular that there is no assurance of sufficient public cooperation to meet the safety need that the standard seeks to address.[106]

---

[103] E.g., *Nat'l Truck Equip. Ass'n v. Nat'l Highway Traffic Safety Admin.*, 919 F.2d 1148, 1153-54 (6th Cir. 1990); *Ctr. for Auto Safety v. Peck,* 751 F.2d 1336, 1343 (D.C. Cir. 1985) (panel opinion by Circuit Judge Scalia).
[104] *Pac. Legal Found. v. Dept. of Transp.*, 593 F.2d 1338, 1345-46 (D.C. Cir.), *cert. denied*, 444 U.S. 830 (1979).
[105] Id.
[106] Pursuant to concerns about public acceptance of various seat belt designs, NHTSA issued a final rule in 1981 adding seat belt comfort and convenience requirements to Standard No. 208, Occupant Crash Protection. Federal Motor Vehicle Safety Standards; Improvement of Seat Belt Assemblies, 46 Fed. Reg. 2064 (Jan. 8, 1981) (codified at 49 CFR Part 571).

The discussion in this section thus far has presented the requirements under the Safety Act for establishing motor vehicle and motor vehicle equipment safety standards; the following discussion will cover how theoretical safety standards for DSRC and DSRC-based safety applications might go about fulfilling those requirements.

2. Safety standards for DSRC

NHTSA would theoretically establish an FMVSS for DSRC in order to enable safety applications such as IMA, FCW, LTA, DNPW, and others. As discussed above, we are assuming here that the FMVSS for DSRC would require DSRC equipment in all new vehicles. For purposes of this discussion, we assume that DSRC would have its own FMVSS rather than have all of its requirements incorporated into FMVSSs for DSRC-based safety applications – this would appear to be preferable to avoid duplication of requirements if multiple safety applications were going to be DSRC-based – although any or all of these FMVSSs could certainly be established simultaneously. This would also permit OEMs to comply with at least some of the safety application FMVSSs using non-V2V technology (e.g., sensor-based FCW technology).

An FMVSS for DSRC must include minimum standards for DSRC performance. This requires a determination of what tasks DSRC must be able to perform. NHTSA has certain performance measures already available as developed for the Safety Pilot,[107] and is also currently working to develop a comprehensive list of DSRC use cases as a basis for developing performance measures that may be more appropriate for an eventual FMVSS, but at its most basic, the DSRC likely must be capable, among other things, of sending and receiving BSMs to other vehicles and to infrastructure; of *not* sending or receiving certain types of information that might be harmful to the vehicle or to the V2V system (including BSMs, if the system recognizes or the DSRC recognizes itself to be somehow compromised); and of receiving new certificates and software updates. Each of those tasks, in turn, has sub-tasks in order to ensure effective performance. For example, when a DSRC unit sends out a BSM, the BSM needs to:

- Contain the relevant elements and describe them accurately (e.g., vehicle speed; GPS position; vehicle heading; DSRC message ID, etc.);
- Be received quickly enough for the receiving DSRC unit to interpret the message and respond accordingly by triggering safety applications or not;
- Contain something to indicate that it should be trusted by the receiving DSRC unit and that the message has not altered (e.g., a signed security certificate that is up-to-date).

---

[107] E.g., System Requirements Description, 5.9 GHz DSRC Vehicle Awareness Device Specification, Version 3.6 (Jan. 25, 2012) at www.its.dot.gov/newsletter/VAD%20Specs.pdf (last accessed Jan. 28, 2014).

In the interest of brevity, this discussion does not contain every current anticipated task and sub-task that would likely be included among minimum standards for DSRC performance – those can be found in Section V.E. For purposes of helping to ensure legal sufficiency, relevant tasks must be identified and minimum standards for DSRC units performing those tasks must be specified. SAE J2945.1, developed in large part through DOT funds, contains minimum performance requirements for BSM communication, but SAE has not yet developed any requirements for message accuracy, test procedures, or how the data and message would be used (such as message transmission rate or optional data usage in various situations), nor is it certain that they will do so in the future. DOT and its research partners have developed performance requirements for the BSM and DSRC to use in the Safety Pilot[108] that the agency believes are adequate for that purpose. SAE has yet to incorporate any of this work, however, in order to develop comprehensive voluntary consensus standards that NHTSA could consider to ensure full DSRC interoperability.[109] SAE's work is still ongoing, but it is likely reasonable to assume that it would be completed prior to a potential future proposal to establish an FMVSS for DSRC. In order to determine the performance requirements for the BSM and DSRC that would be needed to support interoperability on a larger scale, NHTSA will likely rely on the results of the Safety Pilot and other ongoing research, and examine whatever voluntary consensus standards are available at that time and seem applicable. Section V.E discusses the status of the voluntary consensus standards under development that are relevant to DSRC.

A future DSRC standard may also need to include requirements to ensure that messages are able to be received even as more vehicles and infrastructure are broadcasting more often – "message congestion" has not come up in the Model Deployment due to the relatively low density of DSRC-equipped vehicles and infrastructure in Ann Arbor, but may become an issue going forward, especially in heavily populated areas. DOT is sponsoring research to evaluate the capacity of the spectrum and mitigate the effects of channel congestion on DSRC performance; CAMP has also conducted testing, but has been unable to create a situation of channel saturation.[110] Depending on the findings of that research, the agency may want to consider requiring manufacturers to use a particular congestion mitigation algorithm so that the safety applications can continue to work as the broadcast channel approaches capacity. As discussed above, the case law reasonably supports the agency specifying certain design aspects if necessary to ensure proper operation of safety systems.

---

[108] Please see: System Requirements Description, 5.9 GHz DSRC Vehicle Awareness Device Specification, Version 3.6 (Jan. 25, 2012) at www.its.dot.gov/newsletter/VAD%20Specs.pdf (last accessed Jan. 28, 2014) and System Requirements Description, 5.9 GHz DSRC Vehicle Awareness Device Specification, Version 3.6 (Dec.26, 2011) at www.its.dot.gov/meetings/pdf/T2-05_ASD_Device_Design_Specification_20120109.pdf (last accessed Feb. 20, 2014).

[109] See http://standards.sae.org/wip/j2945/ (last accessed Jan. 28, 2014).

[110] For more information, see Section V.E.1.c).

A safety standard for DSRC also needs to meet the need for safety, which means, as discussed above, that there needs to be some nexus between DSRC and the safety problem that a DSRC standard is trying to resolve, but does *not* mean that DSRC must directly create more safety itself, as long as it is enabling other safety applications. On the second point, the case law supports this view – if VINs could be upheld as meeting the need for motor vehicle safety simply by virtue of the fact that they aid research in understanding safety problems and supporting future standards, as well as aiding recall campaigns and tracking of stolen vehicles, then DSRC, which would directly enable half a dozen safety applications at its inception and perhaps many more eventually, seems even more likely to meet the need for safety in that respect.

If the agency decides to issue an FMVSS, we will want to be sure to explain carefully the nexus between DSRC and the safety problems that we are trying to address, depending on the order in which the agency issues FMVSSs for safety applications. There is no doubt that there is *a* nexus – DSRC *can* enable all of the safety applications under consideration by the agency, which means that DSRC can help to address the safety problems of, e.g., intersection collisions, collisions with forward stopped or slowing vehicles, collisions that occur because a driver chose to pass a forward vehicle without enough room to do so safely, etc. As far as we know currently, DSRC is the only technology that can enable Intersection Movement Assist, Left Turn Assist, and Electronic Emergency Brake Light. For some of the other safety applications, which can also be enabled by other technologies besides DSRC, such as on-board sensors, radar, or cameras, DSRC can add robustness to an on-board system. The agency may nonetheless want to develop evidence that a DSRC mandate represents a reasonable technological solution for addressing the safety problems at issue. In sum, DSRC will either be the sole enabler of some safety applications or present a possible enhancement to on-board systems with regard to other applications. In either case, DSRC will address safety needs.

A DSRC standard also needs to be objective. It is likely to be objective, according to the case law, if exact duplication of test conditions yields identical results, and if compliance is based on measurements rather than on subjective opinion. As explained above, while there are test procedures for DSRC performance that were used in the Safety Pilot,[111] test procedures for DSRC performance, survivability, etc. that might be appropriate for an FMVSS have yet to be developed, and research continues. Testing for DSRC will likely require procedures to establish both that the DSRC unit itself is able to receive and transmit the needed messages as timely as needed and without being compromised (recognizing that in the current design, one radio will be used exclusively for sending and receiving BSMs, while the other will be used to communicate with infrastructure and the security system), and that the BSM elements are accurate. Some

---

[111] *E.g.*, Safety Pilot Model Deployment, Deliverable: Interoperability Stage II Test Report, Task 5. See Docket No. NHTSA-2014-0022

examples of tests that could be needed for DSRC message transmission/reception might include tests for:

- Range,
- Latency,
- Ability to transmit,
- Ability to receive,
- Accuracy of GPS,
- Accuracy of information on vehicle speed and heading, and
- BSM performance in a degraded state when GPS is not available.

Some examples of tests that could help to determine the accuracy of the BSM elements might include, among other things:

- Sending an instrumented vehicle through a set of maneuvers and checking whether the BSM is reporting vehicle conditions/activity consistently with what the instruments are reporting;
- Setting up an array of DSRC receivers at a certain distance from the vehicle to test the directional range of the vehicle's broadcast capability;
- Sending a vehicle through a set of maneuvers and checking whether BSMs from that vehicle are received with the required frequency to support particular safety applications; and
- Checking the vehicle's relative reported GPS position against a GPS receiver with a known bias to determine the accuracy of the vehicle's reported relative position.

The agency will have to carefully assess any compliance test that tests the accuracy of GPS to ensure that the test is objective. As one example, atmospheric conditions influence the accuracy of GPS receivers and can cause the same receiver to produce different results, even when the receiver is tested at different times on the same day. Atmospheric and weather conditions also influence the range of radio broadcast capabilities. The agency could adjust the tolerances of the compliance tests to account for factors like this that introduce uncertainty, but this strategy could end up reducing the stringency of the requirements. We also know that there are conditions under which the GPS will not be able to work, such under bridges and in "urban canyons" that exist between tall buildings in urban and city environments. Compliance tests will need to account for these situations, and we are researching methods to compensate for these degradations in performance. These examples help to illustrate the uncertainty that exists in trying to assess the objectivity of potential compliance tests at this time.

And finally, a DSRC FMVSS would need to be practicable – as defined by technological practicability, economic practicability, and public acceptance of the technology.

Technologically, DSRC has existed for over a decade, and is currently being used in Japan to support V2I applications and electronic toll collection. While DSRC may be widely used for some purposes and in some regions, however, ensuring interoperability between vehicles remains an issue needing further research. While comprehensive DSRC performance requirements and test procedures, such as those that would be included in an FMVSS, have yet to be established, it seems reasonably likely that an FMVSS would be technologically practicable assuming that objective tests to ensure interoperability are developed.

In terms of economic practicability, NHTSA currently assumes that the cost of a DSRC standard would include costs for device hardware and software, as well as costs for the security and communications system that would be necessary in order for DSRC to function properly. As discussed in Section XI, we estimate the likely total cost for a V2V system to the consumer (vehicle equipment costs, fuel economy impact, SCMS costs, and communication costs) at approximately \$341- \$350 (7% to 3% discount rate) per new vehicle in 2020. Economic practicability requires that compliance with the standard should not be so burdensome as to create a significant harm to a well-established industry. It does not seem likely that a court would find the standards economically impracticable either for the auto industry, or for any small business interests potentially implicated, since those would more likely be in the context of aftermarket devices (phone apps and so forth), which are entirely voluntary and do not represent a mandate.

For the question of public acceptance, the main concerns with regard to a DSRC FMVSS likely relate to security and privacy. In order to avoid risk that a DSRC standard is not accepted by the public, the standard could likely benefit from security and privacy requirements for message transmission/receipt – for example, that the message does not contain information that could create an unreasonable privacy risk; that the unit is resistant to tampering, hacking; etc. Another requirement related to security that could create public acceptance issues is when and how updates to the DSRC occur. DSRC units will likely need periodic software upgrades and patches, and may need additional security certificates to be uploaded over the course of their lifetimes. If driver action is needed to make those updates successful – for example, if the driver must take the vehicle to a dealership for the work to be done – it is possible that some drivers simply will forgo the effort, leaving themselves less safe and possibly impairing the entire V2V system. NHTSA could try to develop driver alerts as part of a potential FMVSS to help ensure that drivers take that action, but would have to consider how to balance the need to warn drivers against possible public acceptance issues. At this point, NHTSA is optimistic that updates will be able to be performed automatically. Section V.E.4 provides additional discussion on how device updates could be managed so that this can be avoided, but the agency will continue to research this issue going forward.

Policy Need IV-2 V2V Device Software Updates

Policy Need:	V2V Device Software Updates
Description:	V2V device software updates may be required over its lifecycle. NHTSA will need to determine how to ensure necessary V2V device software updates are seamless for consumers and confirmed. V2V devices may become inoperable over time or potentially out of date with system needs as upgrades are implemented. One possible route to address this issue is via terms of use required by the SCMS in connection with providing security services necessary to support V2V communications.

Excessive false warnings may create another public acceptance issue, in that they may annoy drivers and cause them to ignore true warnings if false warnings are too numerous. False warnings may be caused through inaccuracies in a vehicle's reported position, speed or predicted path information: preventing these false warnings will require test procedures to reduce these inaccuracies and mitigation techniques have already been implemented in the Safety Pilot Model Deployment to minimize false positives discovered thus far. Initial analysis of data collected during the second phase of Model Deployment indicates that the false positive mitigation techniques associated with the IMA safety application has reduced the amount of certain false positive alerts observed in the Model Deployment. Additionally, consumer acceptance and practicability of the system is currently dependent on the existence of a security system. If the agency is not able to identify an entity to manage the security system, then that may affect the practicability of any FMVSS mandating DSRC-based V2V, as the security system is currently needed to ensure that messages are trustworthy.

3. Safety standards for DSRC-enabled safety applications

As discussed in more detail in Section VI, the agency is currently investigating six safety applications that could be enabled by DSRC: IMA, FCW, DNPW, EEBL, BSW/LCW, and LTA. We may decide to mandate some or all of these applications, and perhaps also future applications yet to be developed. If we do mandate them, it seems likely that (1) in the interests of stronger enforcement options, they would be incorporated into NHTSA's regulations as an FMVSS, and (2) in the interests of clarity, each would have its own FMVSS. An FMVSS for each of these safety applications must include minimum standards for its performance. This first requires a determination of what tasks the safety applications need to perform, which varies based on the types of safety risks/crash scenarios that the application is intended to address. As further discussed in Section VI, the agency is examining the currently available (research-stage) performance and test metrics associated with each application. Further, the agency is analyzing these metrics against the available safety data to determine whether these metrics cover the applicable safety problem. We envision that each FMVSS for one of these safety applications would set performance requirements that could be met by any technology. For example, FCW might be met through use of radar or cameras, or through use of DSRC. However, if DSRC performance requirements made it reasonable to require more robust performance, we could require that performance when DSRC is mandated. As discussed above, for some applications, like IMA, performance requirements can likely be met *only* with DSRC-based technologies due to their ability to detect crossing-path vehicles, but for others, a variety of technologies could potentially be used.

It would seem clear-cut that FMVSSs for the V2V safety applications meet the need for safety, insofar as we would issue them to address safety problems that continue to cause crashes in the absence of regulation or market forces driving their adoption. The safety applications are clearly intended to relate to safety – they warn drivers of dangerous conditions and are intended to promote safety by triggering a response to avoid the danger.

There are several things that the agency could do to help solidify the nexus of safety application warning and driver response. For example, from a technological perspective, research continues at this point to develop driver-vehicle interfaces for each of the safety applications. We will need to be able to demonstrate how effective the DVIs we may eventually mandate are at warning the drivers and inducing them to avoid the dangerous situation. We currently have reason to believe that the V2V safety applications will meet the need for safety, but our evidence needs to be stronger.

FMVSSs for V2V safety applications also need to be objective, meaning that they specify test procedures that are "capable of producing identical results when test conditions are exactly duplicated" (meaning that the agency and the manufacturer must be able to obtain the same result from identical tests) and performance requirements whose satisfaction is "based upon the readings obtained from measuring instruments as opposed to subjective opinions." As discussed above, test procedures and performance requirements for the V2V safety applications are still being developed, but NHTSA would ensure that any test procedures it may require would meet the criteria of being objective.

In terms of technological practicability, because test procedures and requirements (including those for DVIs) are still being developed for the V2V safety applications, it could be advisable to provide additional lead time to meet eventual standards in order to ensure that manufacturers have the opportunity to work out how to comply depending on timing for a future potential regulatory action.[112] More research will be helpful in informing future assessments of technological practicability.

In terms of economic practicability, NHTSA currently assumes using preliminary cost estimates that the cost of standards for the V2V-based safety applications would primarily include costs for software that would be used by the vehicle to interpret DSRC signals and make decisions about whether to warn the driver, as well as costs for any hardware that would be necessary to make those warnings happen via the DVI. As discussed above, it seems unlikely that economic practicability would be an issue for potential safety application FMVSSs, but more research to determine costs more precisely would be beneficial to this assessment.

Based on the research we have so far from the Safety Pilot, driver enthusiasm for the V2V safety applications appears mixed – *see* Section VII for more information. Given that DVI requirements remain under development, and given that the algorithms currently being analyzed as part of the Model Deployment have a relatively high false positive rate, more work needs to be done before we can be confident that eventual FMVSSs for V2V safety applications will not have public acceptance risks.

The discussion in this section has focused so far on what it would take to establish FMVSSs to facilitate a V2V system, but a V2V system is not complete without communications and security components that NHTSA cannot mandate fully under its Safety Act authority. As discussed at much greater length in Section IV.A, NHTSA has authority under the "necessary expense" doctrine to enter into agreements or contracts to ensure the existence of sufficient communications and security systems to support deployment of V2V technologies as required by FMVSSs. As part of that authority, an SCMS agreement or contract could be designed with adequate government oversight to ensure that the SCMS is supporting V2V communications in a secure, privacy-appropriate way. Some of the likely primary areas covered in an SCMS agreement or contract might include the nature of the services provided, both on an initial and on an ongoing basis; requirements for system access; requirements to foster user/data privacy; requirements for system security; user fees; data ownership and access; liability; enforcement; and what to do in the event of default or termination.

However, if private industry does not establish the required communications infrastructure without government intervention (which is possible), NHTSA will need to exercise its authority to enter into a contract or agreement to establish the necessary communications and security pieces of a V2V system and will need someone on the other end of that contract or agreement. With no appropriations (i.e., no ability to pay the entity performing this role)

---

[112] See discussion above regarding the Sixth Circuit's finding in *Chrysler*, 472 F.2d at 659, 666, and 671-75 (6th Cir. 1972).

currently anticipated for this purpose, the likelihood of success in finding entities willing to take on these considerable tasks will depend on the extent to which private entities can create financial models[113] to support development and operation of the communications and security infrastructure that are consistent with the Department's V2V principles (i.e., no recurring fees for consumers, appropriate privacy and security protections and extensibility to V2I and V2X applications). Thus, having authority is not a guarantee of success in system implementation – the V2V system model is unlikely to work unless private industry moves forward with developing the security and communications infrastructure required for the V2V system or NHTSA is able to reach agreement with the entities who will eventually manage the security and communications systems in a way that encourages their performance but does not create unintended consequences. Potential privacy issues associated with this will be discussed in Section VIII.

4. Discussion of need for additional legal authority prior to taking regulatory actions regarding vehicle to vehicle communication

The agency already has the legal authority between the Safety Act and the necessary expense doctrine to create the pieces needed for a V2V system. We believe that a viable V2V system can be established and maintained under our current authority. However, some have suggested that a system could potentially be better protected if NHTSA had sufficient appropriations to develop the capacity itself to manage the security and communications components of the system, and did not have to rely on contracts/agreements with other parties. NHTSA has no current plans to seek additional funding for this purpose.

C. Non-regulatory actions required to stand up V2V communications

The largest non-regulatory actions needed to create a V2V system, as discussed above, include the possible need to enter into contracts/agreements required to ensure the existence of the communications and security portions of the system (both of which will fall to the security system manager/owners to put in place). These could range in nature from Federal procurement and management of the entities making up the security and communications portion of the system, to procurement solely of the security and communications services themselves, via for cost or no-cost contracts covered by the Federal Acquisition Regulations (FAR), to one or more binding agreements not covered by the FAR with private entities that voluntarily 'stand up' the security and communications parts of the system.

The agency would also need to conduct a number of analyses as part of a potential future regulatory action to establish FMVSSs for DSRC and the V2V safety applications, such as

---

[113] A possible financial model identified by some stakeholders involves charging fees to motor vehicle and ASD equipment manufacturers that the n can be passed on to consumers via equipment costs.

evaluating the potential effect of standards on small businesses, small organizations, and small governmental jurisdictions under the Regulatory Flexibility Act; consulting with State, local, and tribal governments as appropriate and evaluating the preemptive effect of standards under Executive Order 13132 (Federalism); assessing the costs and benefits of the standards and evaluating whether we have selected the most cost-effective alternative under the Unfunded Mandates Reform Act of 1995 (UMRA); determining and disclosing whether we are imposing requirements to collect information under the Paperwork Reduction Act (PRA); and evaluating whether we could have used technical standards developed by voluntary consensus bodies as required by the National Technology Transfer and Advancement Act (NTTAA), among others. Requirements for the agency's analysis under the Privacy Act will be discussed in Section VIII.

Optionally, we may also decide to conduct a consumer education campaign to raise consumer awareness of the benefits of V2V technologies and help address potential concerns about security and privacy. The agency is aware of public concerns regarding the issue of privacy generally, and a campaign could be developed and shaped to provide clear messaging on the many components and operation of the V2V system specifically developed to protect consumer privacy. Additionally, the campaign could also provide clear messaging on the basic operation of V2V, along with the benefits and potential plans for a rollout.

D. Authority for the spectrum in which V2V will operate, and how it could affect the development of a V2V system

DSRC communications are currently designed to travel in a specific band of the electromagnetic spectrum – specifically, around 5.9 GHz, as allocated by the Federal Communications Commission (FCC) in 1999. The FCC has the authority to allocate sections of the spectrum to various uses within the United States,[114] and is currently considering whether to "share" the 5850-5925 MHz bands with "Unlicensed-National Information Infrastructure" (U-NII) devices.[115] This could potentially have serious consequences for the viability of V2V communications. Existing authorizations for U-NII devices allow them to operate only on a non-interfering basis with licensed services. Issues regarding spectrum will be discussed further in Section V.D.2.

U-NII devices provide short-range, high-speed unlicensed wireless connections in the 5 GHz band for, among other applications, Wi-Fi-enabled radio local area networks, cordless telephones, and fixed outdoor broadband transceivers used by wireless Internet service providers. On April 10, 2013 the FCC published in the Federal Register, a Notice of Proposed Rulemaking

---

[114] 47 U.S.C. § 303.

[115] FCC docket for this issue. See http://apps.fcc.gov/ecfs/proceeding/view?name=13-49 (last accessed Jan. 28, 2014).

to revise Part 15 of its Rules to permit U-NII devices in the 5.580-5.925 GHz band.[116] DOT submitted comments to the FCC NPRM to the National Telecommunications and Information Administration and NTIA filed those comments with the FCC June 10, 2013.[117] The June 10, 2013 comments indicated DOT's technical concerns related to spectrum sharing with U-NII devices in the 5.9 GHz band, that identified the absence of (1) any proposed technical sharing solution with U-NII devices that would definitively maintain the channel (or medium) access required to guarantee interference-free operation of the critical safety applications; or (2) an assessment of the technical risk to Connected Vehicle safety operations of potential interference from U-NII devices. DOT plans to remain actively involved in the ongoing discussions and technical analyses relating to the FCC rulemaking proceeding and will continue working with NTIA on this spectrum issue.

---

[116] 78 Fed. Reg. 21320, at 21321(Apr. 10, 2013).
[117] DOT's comments, as submitted by NTIA. See: http://apps.fcc.gov/ecfs/comment/view;jsessionid=hGpQRykFTJLGq48qstFl7wBR2RvJbHBFhCbt470V7ykR1fTvQ2Wy!-528136363!-1469015862?id=6017448690 (last accessed Jan. 28, 2014).

V. Technical Practicability

A. Technical practicability and its importance to an agency decision

Technical practicability is a measure of how feasible a standard is given the technology options that are available to meet it. Significant technical uncertainties in meeting a standard might lead a court to find that a standard is not practicable. V2V technology is currently fairly mature – certainly mature enough to function in the Safety Pilot – and we anticipate that future research will address any lingering uncertainty with how either DSRC or the safety applications should function. The following discussion covers the current state of the agency's knowledge of the different pieces and parts necessary for a V2V system, their technological readiness, and what research may be appropriate going forward. This section does not discuss the security of V2V communications nor the system contemplated to ensure that security, both of which are addressed in Section IX.

B. Overview of hardware components enabling system operation

In general, two sets of components are needed for V2V communications to operate. The first set of components are those required for a device to transmit an accurate and trusted basic safety message and the second are the components needed for a device to receive and interpret a BSM transmitted from another entity.

To *generate and send* a BSM, a device needs to know its own position (such as via a GPS antenna and receiver). Once its position is known, the device needs a computer processing unit that can take its location and combine this with other onboard sensors (e.g., speed, heading, acceleration) to generate the required BSM data string. Once the BSM is generated, a device is needed to transmit this message wirelessly to another vehicle. As the onboard processor is generating the BSM, a security module is processing and preparing the security information and certificates for transmission to provide the receiving vehicle assurance that the message is valid. This security information needs to be transmitted wirelessly as well.

To *receive and interpret* a BSM, a device must be capable of receiving the BSM that is transmitted from a nearby device and it must match the method of BSM transmission (i.e., if the message is transmitted via DSRC, the receiving device must have a DSRC receiver). It also must have a computer processing unit that can decode the BSM properly. A GPS antenna and receiver are needed to verify the relative distance between the sending device and the receiving device. Lastly, the device that is receiving the BSM must also have a security module that is capable of receiving and processing the security credential information as well.

Lastly, to operate the safety applications adequately to warn drivers, a driver-vehicle interface is needed to display critical advisories and imminent alerts. This DVI may take the form of a visual heads-up display or infotainment screen displays, LEDs and blinkers located strategically around the driver's field of view, audible noises, and/or haptic feedback peripherals.

1. Components used in testing

DOT has conducted a significant amount of research on DSRC-based vehicle-to-vehicle communications. In 2012, building on this research, the Department initiated the Safety Pilot Program in Ann Arbor, Michigan, in order to collect data to be used to evaluate V2V technology in relation to light vehicle operations. The different types of DSRC-based devices, used in the vehicles that were deployed in Ann Arbor, are: (1) Integrated Vehicle Devices (OEM devices) , which were installed (integrated by OEMs) into 64 new vehicles (8 per the 8 OEMs participating in the Safety Pilot); (2) Aftermarket Safety Devices (elsewhere called "self-contained" devices), which were installed into 270 light vehicles supplied by volunteer subjects; (3) Vehicle Awareness Devices, which were installed in over 2,400 volunteer private vehicles and various fleet vehicles such as schools buses; and (4) Integrated and Retrofit Safety Devices, which were also installed in heavy trucks (19) and transit buses (3) to support later evaluation of heavy truck and transit bus safety applications.

These DSRC-based devices had varied characteristics and served different purposes in being included in the Program. The main device, an integrated vehicle device, is an electronic device that is inserted into a vehicle during its manufacture. This type of device is connected to proprietary data buses and can provide highly accurate information using in-vehicle sensors to generate the BSM. It can both broadcast and receive BSMs, as well as process the content of received messages to provide warnings and/or alerts to the driver of the vehicle in which it is installed.

As described in Section III.D.2.a), an aftermarket safety device, as used in the Safety Pilot context, is an electronic device installed in a vehicle after its original manufacture, which is capable of both sending and receiving safety messages over a DSRC wireless communications link. This type of device has a driver interface, can run V2V and V2I safety applications, and can issue audible advisories or warnings to the driver of the vehicle. Some of the devices are integrated into the vehicle's existing computer systems and are referred to as Retrofit Safety Devices (RSDs).[118] They can receive information from the vehicle data buses and on-vehicle sensors. Other devices are not connected to the vehicle's data bus. They receive the information needed to form the BSM from the device's GPS, and they can also be equipped with additional sensors to provide more accurate information for the BSM.

---

[118] Retrofit devices that are connected to the vehicle computer system are being used in the safety pilot on transit vehicles and trucks. See Safety Pilot Information Sheet at www.its.dot.gov/factsheets/safety_pilot_factsheet.htm (last accessed Jan. 28, 2014).

A VAD is an aftermarket electronic device installed in a vehicle without connection to vehicle systems, which is only capable of sending the BSM over a DSRC wireless communications link to alert other DSRC-equipped vehicles to its presence. Because VADs are not connected to the vehicle's computer systems, all of the information for the BSM is derived from the device's GPS.[119] Additional sensors in these devices such as accelerometers or gyros can be used to provide more accurate information for the BSM. Because VADs are not equipped with a driver interface, they are not capable of generating warnings. VADs may be used in any type of vehicle, regardless of the vehicle's age or onboard electronic systems.

2. Components required for V2V system operation

A V2V communication system requires components located in vehicles and along roadways to enable complete system operation. For a V2V system, this includes both the vehicle-based components and road side equipment (RSE) units to provide security updates and communication to the security management system. A V2I system would expand capabilities by embedding additional RSEs, potentially, in traffic signals, signs, and other infrastructure-related components. The following sections provide details on vehicle and non-vehicle based components.

3. Vehicle-based hardware

At a minimum, V2V devices would require two DSRC radios[120] and a GPS receiver with a processor to derive information such as vehicle speed and predicted path from the device's GPS data. To improve the quality of the data that vehicle-based components could use to issue warnings, an inertial measurement unit to detect acceleration forces would be needed. In addition, a driver-vehicle interface would be essential for issuing warnings to the driver. Such warnings could be audial or visual (with the corresponding required hardware), or, for devices fully integrated into the vehicle at the time of manufacture (i.e., vehicles with Integrated Safety Systems), the warnings could potentially be haptic warnings (e.g., tightening of the seat belt, vibrating the driver's seat).

NHTSA also foresees the potential for V2V safety systems to be integrated into an existing electronic control unit(s) during large-scale production of vehicles equipped with these systems. Figure V-1 illustrates the vehicle-based components needed for an integrated V2V system that uses integrated vehicle devices. (A V2V system with ASDs would only differ in its lack of connection to the vehicle's internal communications network.)

---

[120] See Section V.D.2 below for more information on why NHTSA believes two DSRC radios would be necessary.